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Editorial

EDITOR
Ben Hardwidge
editor@custompcmag.org.uk

LABS
Matthew Lambert
Orestis Bastounis

MODDING EDITOR
Antony Leather

GAMES EDITOR
Rick Lane

ART EDITOR
Bill Bagnall
www.billbagnalldesign.com

PRODUCTION EDITOR
Julie Birrell

CONTRIBUTORS
Gareth Halfacree, James Gorbold, Mike Jennings, Paul Goodhead, Richard Swinburne, Simon Treadaway, Tracy King

PHOTOGRAPHY
Antony Leather, Gareth Halfacree, Mike Jennings

Publishing & Marketing

GROUP PUBLISHER
Paul Rayner
paul_rayner@dennis.co.uk

LICENSING MANAGER
Carlotta Serantoni
Carlotta_Serantoni@dennis.co.uk
+44 (0)20 7907 6550

LICENSING & SYNDICATION ASSISTANT
Nicole Adams
Nicole_Adams@dennis.co.uk
+44 (0)20 7907 6134

SYNDICATION SENIOR MANAGER
Anjum Dosaj
+44 (0)20 7907 6132

Commercial & Advertising
Paul Rayner
paul_rayner@dennis.co.uk

Dennis Publishing Limited
Tel: 020 7907 6000 fax 020 7907 6193

DIRECTOR OF ADVERTISING
Julian Lloyd Evans

MANAGING DIRECTOR DENNIS TECHNOLOGY
John Garewal

CEO
Ian Westwood

NEWSTRADE DIRECTOR
David Barker

FINANCE DIRECTOR
Brett Reynolds

GROUP FINANCE DIRECTOR
Ian Leggett

CHIEF EXECUTIVE
James Tye

COMPANY FOUNDER
Felix Dennis

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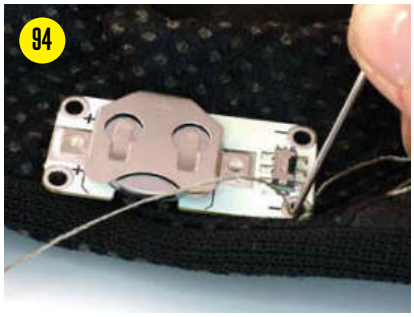

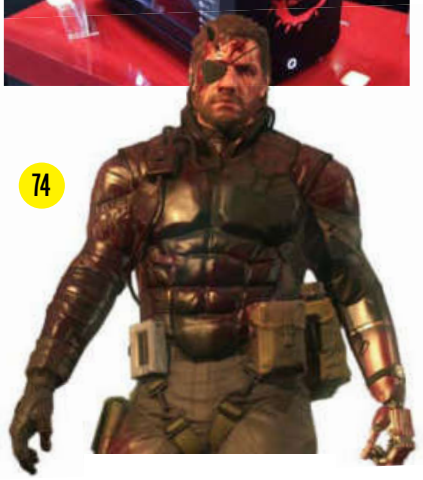

Regulars

Cover guide

Reviewed this month

32 PRODUCTS REVIEWED

Reviews

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Z170 Motherboard Labs

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BEN HARDWIDGE / FROM THE EDITOR

M.2 IS A SHAMBLES

Multiple sizes of cards and interface standards have made M.2 practically incomprehensible, argues Ben Hardwidge

There's a part of me that misses IDE cables. They might have taken up loads of space, and routing them neatly meant taking a masterclass in origami, but if you bought an IDE hard drive, you knew it would work with your system. There might have been several UDMA speed variations, but they were all backwards compatible if you were prepared to sacrifice speed. Of course, there were obvious reasons why we needed new storage interfaces, but IDE looks so remarkably simple compared to the current shambles of storage 'standards'.

The Z170 motherboards we've reviewed in this month's Labs test (see p38) have to support a variety of different ports, sockets and standards to tick all the necessary feature boxes. There are regular SATA 6Gpbs ports and SATA Express ports, which are basically a couple of SATA ports strung together with a third new connector. It's a bit like the storage equivalent of VESA local bus – for those of you without grey beards, VESA local bus was a clunky 32-bit expansion system that bolted a new PCI-esque slot onto a 16-bit ISA slot, resulting in needlessly massive cards – it was soon rightly replaced by PCI. SATA Express is the same – an interim mishmash of technology that hardly anyone supports, and which is going to be rendered obsolete by M.2 anyway.

That's if M.2 can get its act together. I've been into tech a long time, but I don't think I've ever seen such a shambolic approach to creating a tech standard. Firstly, there are different sizes of M.2 devices, so you need to make sure your M.2 slot can physically accommodate your chosen device. This is a nuisance itself, but then you have to wrestle with the interface standard.

Some M.2 devices only support SATA, which means they offer no speed advantage over a standard SATA drive. Some devices support PCI-E with AHCI, and others support PCI-E with the new NVMe standard. It's not just the device though. You also need to look at what your slot supports. Not every PCI-E M.2 slot is equal; some only offer two lanes, while others offer four, and some only support PCI-E 2, rather than the quicker PCI-E 3 standard.

To make matters worse, makers of M.2 devices don't even seem to understand their market. For example, Samsung has refused to send us review samples of its SM951 M.2 SSDs, as it says the product is only for professional users, yet system builders regularly put these drives into enthusiast gaming systems.

> We have a fiasco where people don't know if the M.2 device they want will work with their board

We're now left with a fiasco where many people don't know if the M.2 device they want will work with their board, meaning they just avoid the whole situation entirely. It's also further complicated by other factors – not every motherboard will boot from an NVMe drive, for example – if you own such a board, you may be able to use your NVMe drive for data storage, but you'll need another SSD for Windows.

This muddled approach to standards might be acceptable in the world of laptop building, where a manufacturer decides which size and standard its device will support and makes it accordingly. However, it's not acceptable on the desktop, where people like to mix and match components, and standards need to be clear.

Will Z170's support for 4x PCI-E 3 M.2 devices help to push towards a simpler system? We now have two chipsets (X99 and Z170) that support this standard. However, the size of M.2 device you can install still depends on the motherboard you choose. Either way, makers of M.2 devices and need to stop faffing around, communicate properly with each other and nail down a comprehensible standard. CPC

Ben Hardwidge is the editor of Custom PC. He likes PCs, heavy metal, real ale and Warhammer 40,000. editor@custompcmag.org.uk @custompcmag

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RICHARD SWINBURNE / VIEW FROM TAIWAN

STARTUP RENAISSANCE

Niche startups, such as Parvum, that are in touch with PC enthusiasts, are making big firms look like embarrassing dads, argues Richard Swinburne

While we're seeing a slowdown of PC sales, the often-touted death of the PC has been largely overstated, especially in the innovative land of startup firms. Of course, the PCs and laptops that were found in family homes and student digs a decade ago were mostly used as internet machines and word processors rather than powerful computers, and they're often being sensibly replaced with tablets and smartphones. Meanwhile, businesses may still be using PCs, but they're spending longer between upgrade cycles.

However, PC gaming, workstations and the enthusiast segment remains very strong. So, while big-volume PC businesses such Acer, HP and Lenovo are struggling, PC component manufacturers have pivoted towards gaming branding. Sadly, though, the gaming branding also seems to come with a strategy of shying away from genuine innovations and risky ideas, and is instead playing it safe with similar designs to the competition.

> The majority of modding articles that go viral feature water-cooled builds

I truly hope we've now reached the peak of gaming branding, lest we suffocate further with the embarrassingly dad-like embrace of big companies' attempts at marketing to gamers. But the upside of big companies behaving in this way is that it's left a sizeable gap in the pure enthusiast ecosystem, which has yielded a great opportunity for niche startups to fill the gaps with cool ideas and real innovations.

Recently we've seen BitFenix, Raijintek, and more recently Parvum and Hex Gear, enter the chassis and cooler fray, sporting innovative and attractive designs that cater for enthusiast needs without resorting to embarrassing gaming branding.

Of course, making a case requires much less in the way of precision engineering and machinery than a motherboard, so it's unlikely you're going to see the next ROG competitor pop up overnight. Having said that, though, the explosive growth of mini PCs, maker events and the multi-million-selling Raspberry Pi means it's not impossible in the future. What's more, with Windows 10 now having an IoT edition, the crossover between the PC and startup designs is ever closer.

Social media is key to generating a core fan base and sustaining noise for these new startups' brands and products – it's exactly how firms such as Case Labs, Parvum and Hex Gear all primarily interact with their customers and the modding community. Meanwhile, sponsorship of modders from companies such as EK and BitsPower also make big waves, as the overwhelming majority of modding articles and project logs that go viral on the Internet feature water-cooled builds.

With EK just launching its all-in-one cooler, called the Predator, we're seeing a fresh attack on incumbents such as Corsair or Cooler Master, with their heavily patented all-in-one liquid coolers. Likewise, Alphacool's GPX-Pro (see p100) combines a radiator, pump and GPU waterblock, while enabling you to use standard water-cooling fittings.

We're even seeing startups making PSU gear. Of course, PSUs can't easily be made by outsiders from scratch, but third-party manufacturers of PSU accessories, such as Shakmods (another UK startup) are providing enthusiast gear such as cabling accessories, which you rarely see from the big companies – notable exceptions being Corsair's individually sleeved and coloured cable kits, and SilverStone's replacement cables.

Otherwise, though, the standard big PC companies need to realise the great opportunities provided by working with these more in-touch startups. They could then start to generate new trends, propelling the industry forwards, rather than simply waiting for Intel or Nvidia to lead it in slow steps. **CPC**

Richard has worked in tech for over a decade, as a UK journalist, on Asus' ROG team and now as an industry analyst based in Taiwan @Bindibadgi

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Letters

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Real-life mods

I've just got back from Insomnia 55, where I met my favourite YouTuber DanTDM, and had a good look around the Expo hall, where I saw the Asus ROG Sica (and left £25 lighter as a result).

However, the most interesting part of the day was seeing Pandora's Purple Box, and Team Magoo's Lumo on the OCUK and In-Win stands respectively.

I'm sure you know how you can never really appreciate a mod until you've seen it in real life, and this was certainly true for these two. Seeing the water-cooling systems bubbling away is really something, especially when you see people coming to look at the mods who probably don't even read any PC mags, and seeing them 'oohing' and 'ahhing' at these machines. Modders must be really proud to hear the nice comments from these strangers. I advise any others readers to take these opportunities to see the machines featured in Readers' drives.

MATT VAUGHAN

Ben: Yes, even the best photography doesn't get across the experience of seeing these machines in action – there really is some amazing PC modding talent out there, and it's often on display at these types of events. I'm glad you had the pleasure of seeing these machines in the flesh, as it were.

The photos of Pandora's Purple Box already look good, but you can't beat seeing the real thing in the flesh

Worthless wrist straps

I just read the letters page in Issue 145 and, as a modding newby, I would really appreciate guidance on tools and methods appearing in the magazine. From recent personal experience, I've found that many antistatic wrist straps aren't worth a penny because the crocodile clip isn't electrically connected to the earth/ground plate on the wrist strap.

I checked out a strap with a multi-meter because the 'free with other hardware' offer I'd taken up seemed too good to be true, and it certainly was. After trying two different types, I've still not found a really good one. What's more, online retailers don't understand them – I returned one for being faulty to be told: 'no postage refund – it is not faulty – we cannot see anything wrong with it' – their returns staff clearly don't get issued with multi-meters.

If you're going to use an anti-static wrist strap, I strongly recommend checking it first for electrical continuity – you can do it by just using a battery and torch bulb – if there's no connection, then there's no ESD discharge path. I'm now prepared to pay for a functional wrist strap, rather than using free ones, to protect my expensive memory hardware.

BOB STIMPSON (MANXBOB ON FOLDING@HOME)

Ben: I'll put my hand up here, and say that I don't think I've actually used an anti-static wrist strap since the 1990s – I usually just ground myself by touching the metal on my case when it's earthed via the mains. That's an interesting find though – the crocodile clip would indeed need to make a connection with the grounding plate to be worth using; I wonder how many PCs have been built using wrist straps that don't work.

M.2 confusion

Thanks for a great mag. I wanted to ask you if you could consider something. As more M.2 drives are appearing and with Skylake, can you specifically state if the M.2 device or interface to which you're referring is SATA or NVMe? I think you would agree that a SATA-only-capable M.2 slot is disappointing and almost pointless, whereas the only M.2 slots we really want are NVMe-capable ones?

Or have I totally misunderstood the tech? I thought you needed motherboard support as well as an NVMe drive to make the magic happen, or are all M.2 slots capable of supporting NVMe, maybe via a BIOS update? It would be horrible to buy a great reviewed motherboard with M.2 support to find it didn't support NVMe, no?

DR ASIF ANWAR

Ben: Indeed, not every M.2 slot or device is the same. Some use SATA, some use PCI-E with AHCI and some use PCI-E with NVMe. To make matters

M.2 devices can be exceptionally fast, but you need to make sure your device and slot both support the same standards

> I'm sure you know how you can never really appreciate a mod until you've seen it in real life

more confusing, some chipsets allocate different numbers of PCI-E lanes to M.2 devices, and support different PCI-E generations. What's more, you also have size compatibility issues, with some slots not being able to accommodate larger cards. It's all a bit of a confusing mess at the moment, but your best bet at the moment is to go with an X99 or Z170 motherboard if you want to install a PCI-E NVMe M.2 device, as they can allocate four PCI-E 3 lanes to it and support NVMe too. We'll try to make our M.2 coverage clearer from next issue onwards.

OEM flip-flop

First let me say I immensely enjoy the mag and subscribed a year or so ago. My letter to you today concerns Windows licences. With Windows 10 recently being released, I was looking to buy the new OS. Of course, this situation has sent me spiralling into the depths of Microsoft legal purgatory.

I know that Microsoft's policy on OEM licenses has flip-flopped on the issue of system builder licences for personal use between the pre-7 licences to 7, back again for 8, only to disallow the practice again in 8.1. With no information coming out of Redmond at the moment, I turned to your mag for guidance only to find that the Windows versions you list under the Elite list are the very OEM versions that (I believe) don't allow personal use.

I know that Windows licensing has always appeared to be a dark art, and OEM licensing for personal is a grey area, but are you recommending that your readers breach their licence agreements? I may, of course, have the wrong end of the stick, and would happily be corrected if I'm wrong. If you could offer any clarity on the use of OEM licences for personal builds (particularly for Windows 10) I'd be forever grateful.

RICHARD SMITH

Ben: Well, researching this situation has been a bit of an eye-opener, and it looks like you're right – OEM licences aren't always licensed for personal use. It used to be the case that you had to buy the OEM software at the same time as a piece of hardware, but it was on the understanding that you would have to replace it if you bought a new motherboard. So, yes, Windows 7 OEM licences aren't condoned for personal use, Windows 8 OEM licences are fine, and with Windows 10 (and Windows 8.1), we're now back to OEM licences not being for personal use.

We were also in a difficult situation with Windows 7, because we didn't want to recommend Windows 8 when it was released. We used to recommend the retail version of Windows 7, as it's important for enthusiasts to know they can upgrade their motherboard, but towards the end, Microsoft pulled the plug on the retail version and you could only buy the OEM version.

So yes, it looks like we were indeed recommending Windows 7 OEM versions that weren't strictly licensed for personal use, for which I apologise – it was a genuine error made with the assumption that, as with Windows 8 OEM licences, the licences would be fine – thank you for bringing it to our attention. However, given that Windows 7 OEM licences were so easily available to buy from retailers, I'd wager that Microsoft isn't particularly bothered about it.

Either way, we're recommending the retail version of Windows 10 on the Elite list now, so you can be sure the version of Windows we recommend is licensed for personal use. CPC

Only Windows 10 retail editions are licensed for personal use

Twitter highlights

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ArcticMartyn Look who decided to stop by! Now waiting for Mr Tool-kit to show up.

kieraanv Couldn't agree more with this article about WMC! Best thing I ever made with an HD quad tuner!

JayBlanch flower Celebrating my Orgasmatron PC in Custom PC mag 10 years ago next week.

Ben: I remember Orgasmatron being featured in Readers' drives very well, that was a really great mod – can't believe it was ten years ago.

WHEN'S THE NEXT MAG COMING OUT?

Issue 148 of **Custom PC** will be on sale on Thursday, 12 November, with subscribers receiving it a few days beforehand.

NOV 12

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TRACY KING / SCEPTICAL ANALYSIS

GREEN GAMING

Tracy King analyses a study that suggests high-performance gaming PCs consume the equivalent power of ten games consoles

Video games are now apparently responsible for ruining the planet, and a whole generation of PC gamers has single-handedly doomed the human race to extinction through global warming. What have we done this time? Our gaming machines aren't energy-efficient, according to a new study, and we're in trouble. Before you don your tinfoil hat, though, I'm not debunking climate change or humankind's contribution to it – that's a matter of scientific fact. The question here is whether high-performance gaming PCs are a significant contributor and, if so, what can or should we do about it?

The answer to the first part is yes, and no. High-performance gaming PCs as a group do use a lot of energy compared with, say, fridges but very little compared with the Las Vegas strip. The difference is that we need fridges, but we don't need high-performance gaming PCs or Las Vegas. It's only fair to compare energy consumption of luxury items with other luxury items, and in that regard, gamers do well in the green stakes compared with VW owners or people with heated pools, but badly compared to console owners.

The study is called 'Taming the energy use of gaming computers' and is by Evan Mills of Lawrence Berkeley National Laboratory, who was part of the team that won the 2007 Nobel peace prize with Al Gore, and his son, Nathaniel Mills of website Greening The Beast (**http://tinyurl.com/GreeningTheBeast**).

Both are gamers and environmentalists who, according to the site, were 'in the process of building our own gaming machine [when] we discovered two important things: 1. It can cost a bundle to run a gaming computer – think hundreds of dollars a year, depending on hardware, use, and energy prices. 2. There was almost no info out there on the energy use of Gaming Machines, especially measured data.'

Saving a few quid per year in the grand scheme of building and running a rig doesn't make me care. But unlike off-the-shelf electronics such as fridges, which have handy energy-efficiency rating stickers, custom PCs are a wild west of power consumption, and there's no reason we should consider ourselves exempt from social responsibility, although I don't think we're *more* irresponsible than anyone else or Vegas.

The authors offer some potentially useful tips at **http://tinyurl.com/GreenPCTips** too. As Evan Mills said to me, 'We're actually not advocating that people stop gaming or even reduce it, only to look at ways of specifying more efficient rigs. Even if the environment isn't considered important, inefficient gaming PCs also release tonnes of heat and are noisier than efficient ones, so, it's a win-win proposition.'

> Fridges have energy-efficiency stickers, but PCs are a wild west of power consumption

The Mills' study is, by their own admission, limited. They estimate that 'the typical gaming PC (including display) uses about 1,400 kWh of electricity per year. The energy use of a single typical gaming PC is equivalent to the energy use of ten game consoles, six conventional desktop computers or three refrigerators'.

They base this figure on an average daily gaming time of 4.4 hours, which seems about right, but it's US-orientated so any financial estimates aren't relevant elsewhere, and the power consumption estimates are based on nameplates; as you probably know, these don't always bear much relation to the actual power used. However, the study is a useful contribution to an area that, as environmental concerns become more the responsibility of individuals, is bound to get the attention of the gaming PC community eventually. CPC

Gamer and science enthusiast Tracy King dissects the evidence and statistics behind popular media stories surrounding tech and gaming @tkingdoll

Incoming

We take a look at the latest newly announced products

Samsung announces super-fast M.2 SSDs

Samsung has just announced two new M.2 SSDs that promise to smash speed records. The new SSD 950 Pro range supports NVMe over four PCI-lanes, and Samsung says the new drives can perform sequential reads at up to 2,500MB/sec, a speed the company says is 4.5 times the speed of its current SSD 850 Pro 512GB SATA drives. Meanwhile, the claimed sequential write speed of 1,500MB/sec isn't quite as jaw-dropping but is still massively quicker than a SATA drive.

The new drives use Samsung's UBX controller and are equipped with 512MB of DDR3 cache. The company says the new drives also consume ve little power, drawing just 5.7W at full load. The drives come in both 256GB a 512GB flavours, and we'll be reviewing the drives in our next issue.

Corsair unveils new RMx PSUs

Corsair has added a new line-up of PSUs to its already expansive range. The RMx power supplies are fully modular for easy cable tidying, and feature 80 Plus Gold certification. Meanwhile, the 140mm cooling fan only spins up when it's needed, ensuring there's no fan noise when it's under low loads. The RMx comes in 550W, 650W, 750W, 850W and 1,000W flavours, with prices at **www.scan.co.uk** starting at £70 inc VAT for the 550W model, and going up to £130 inc VAT for the 1,000W unit.

Arctic goes semi-passive

Cooling manufacturer Arctic has launched a new CPU cooler with semi-passive operation, without needing to spin up the fan during what Arctic calls 'typical Windows operation'. The cooler comes in two versions – the I32 for Intel CPUs and the A32 for AMD chips. Arctic says its new fan controller doesn't start up the PWM-controlled fan until it hits a certain temperature, starting at 40 per cent speed. The I32 is available from **www.amazon.co.uk** for £30.60.

Nvidia launches Shield TV box

Nvidia has just announced that it's bringing its Shield Android set-top box to the UK, with claims that's 'up to 34 times faster and has significantly more features than other popular media streamers'. The device is based on the company's Tegra X1 SoC, which features an 8-core 64-bit ARM CPU and an integrated GPU that's bolstered by 256 stream processors.

The big feature touted by Nvidia is the ability to stream 4K video content from services such as Netflix, with a 60Hz refresh rate possible from its HDMI 2.0 interface. Other hardware features include 7.1 and 5.1 pass-through via HDMI, plus 802.11ac Wi-Fi and Ethernet network connections.

In addition, the Shield box will be able to play a number of Android games, and will also hook up to Nvidia's newly announced GeForce Now service. Like the now defunct OnLive service, GeForce Now promises to stream a number of top-end PC games to the device, saving on the need for dedicated PC hardware. The launch titles include The Witcher III: Wild Hunt, various Batman and Lego titles, and Saints Row: Gat out of Hell.

Prices for the Shield box start at £149.99, including a controller, while a subscription to GeForce Now will cost £7.49 per month. See **http://shield.nvidia.co.uk** for more information.

Reviews

Our in-depth analysis of the latest PC hardware

Reviewed this month

HOW WE TEST
PAGE 32

NAS BOX

Thecus W2000 / £310 inc VAT

SUPPLIER www.amazon.co.uk

Thecus' W2000 distinguishes itself from much of the usual dual-bay competition by using Windows Server 2012 – essentially a massively cut-down copy of Windows 8, instead of an in-house OS. In fact, the OS is so cut down that you have to install many services to even be able to create shared network folders.

As you're using a Windows OS, though, many programs your average PC enthusiast needs from a NAS are easy to install, plus you can install your own backup or cloud services such as Dropbox too. It makes the W2000 hugely flexible, but there's no getting away from the fact that, for the most part, delving any deeper, or carrying out relatively mundane tasks such as creating shared folders, can be a challenge that's not for networking novices.

In order to access the W2000, you need to download and install Windows Server Essentials Connector, which adds your PC to the list of connected computers, enabling it to talk to the NAS. Incidentally, this process didn't seem to work on Windows 10, even if it was run as Administrator and in Windows 7 compatibility mode. It's all a little clunky compared with a Synology NAS, to which you can connect a computer in a matter of seconds, and from a variety of operating systems. Comparatively, it took us nearly an hour to set up the W2000 ready for testing.

The Windows version of Plex installed without a hitch

Hardware-wise, it sports a dual core, Hyper-Threaded Intel Atom D2701, 2GB of DDR3 memory and includes a 2.5in SSD to act as the OS drive, rather than using integrated flash storage.

Meanwhile, its two drive bays support either 2.5in or 3.5in drives and have lockable doors. The front sports a USB 3 port and SD card reader, while at the rear, there's a further two USB 2 ports, an eSATA port, two Ethernet ports that support link aggregation, as well as HDMI and VGA outputs. To control the W2000, you can also hook up a keyboard, mouse and monitor, or connect to it remotely via a browser.

Being Windows-based, there's plenty of scope for creating a very flexible media centre too, and the Windows version of Plex installed without a hitch.

Even more impressive was the fact that the Atom CPU managed to transcode 1080p video on the fly to an iPhone using Plex, although the CPU was above 90 per cent load the whole time.

Transfer rates peaked at a little over 100MB/sec when reading large video files, with our usual large file test seeing average read and write speeds of 85MB/sec and 71MB/sec respectively. Meanwhile, our torturous small file test saw these rates drop to 22MB/sec and 19MB/sec, which are still good results for this test. Sadly, though, while the W2000 only consumed 23W when idle, it's quite noisy compared with the latest Synology and QNAP NAS boxes.

Conclusion

The W2000's use of Windows gives it huge potential, but it's comparatively pricey, the complex setup procedure is a problem, especially when compared with Synology's offerings, and it has a noisy cooling fan. Its diminutive size and power draw mean it's still an attractive media server compared with a cheap PC, but if you must have a small Windows-based NAS, you could also consider an Intel NUC with Windows 10 or FreeNAS installed, which would be much easier to set up.

ANTONY LEATHER

SPEED	FEATURES	VALUE	OVERALL SCORE
30/35	26/35	21/30	77%

VERDICT

The use of Windows makes the W2000 very flexible, but setting it up is challenging and it isn't as easy to use as many Linux-based competitors.

GRAPHICS CARD

AMD Radeon R9 Nano / £500 inc VAT

SUPPLIER www.overclockers.co.uk

AMD has taken the Fury X's Fiji GPU, put it in a dual-slot card that's just 6in long, and is claiming it's cool, quiet and capable of high-detail 4K gaming. All of the R9 Fury X's 4,096 cores, 256 texture units and 64 ROPs are enabled in the R9 Nano. It also has the same 4096-bit wide memory bus, which is connected to 4GB of HBM. HBM has a far smaller physical footprint than GDDR5, as it's integrated onto the same ASIC as the GPU, which is the key enabler of the Nano's size.

Furthermore, while Fury X is clocked at up to 1,050MHz, the Nano is rounded off at up to 1GHz, although the memory is left at 500MHz (1GHz effective). The key, of course, is the phrase 'up to'. With Fury X, the card's closed-loop cooler ensures it comes nowhere near its thermal limit. AMD also gives it a very high power limit, quoting 275W as its typical board power (the true limit is higher but not shared).

This limit drops to 175W for the Nano, and that's the second key part of the size equation. Power consumption is positively correlated to heat output, so slashing the power limit is needed to keep it effectively cooled with such small dimensions. However, this setup also means the card will throttle, unlike the Fury X. Its temperature-based throttling kicks in at 85°C but the real limit is going to be power. That said, the card uses a single 8-pin PCI-E power connector and is thus technically capable of drawing up to around 225W.

The performance is awesome considering its total volume

Another part of the engineering is a binning process – AMD selects only its most efficient GPUs for the Nano. It also cuts the GPU VRMs from six in Fury X to four here, further reducing heat and saving space.

The final element, of course, is the cooler. It uses a single fan that's as large as possible given the dimensions. The shroud is open and the horizontal, full-length fins will guide out hot air both through the rear I/O panel, where there's plenty of ventilation, and back into your case.

The GPU and HBM are cooled by a copper vapour chamber, but a heatpipe and metal plate are also used to help draw heat away from the VRMs and the rest of the PCB. It's a well-considered design that makes maximum use of the card's limited volume.

Display outputs include three DisplayPort 1.2 connectors and an HDMI 1.4 plug. The lack of DVI is forgivable but missing HDMI 2.0 is silly – it's the primary way of driving 60Hz 4K televisions. The Nano also supports CrossFire over XDMA, so no physical connector is needed, and it's been shown to work in CrossFire with a Fury X too.

There's no true competitor against the Nano. It's clearly a premium card, and based on pricing alone it's up against the mighty GTX 980 Ti. However, that would ignore the point of this card – its size. There are third-party GTX 970s that compete in this sense, but of course, they're less powerful and cheaper.

/SPECIFICATIONS

Graphics processor AMD Radeon R9 Nano (up to 1000MHz)

Pipeline 4,096 stream processors, 64 ROPs

Memory 4GB HBM, 1GHz effective

Bandwidth 512GB/sec

Compatibility DirectX 12, Mantle, Vulcan

Outputs 3 x DisplayPort, HDMI

Power connections 1 x 8-pin, side-mounted

Size 152mm long, dual-slot

Performance

Across our tests, the GTX 980 Ti and R9 Fury X are faster than the R9 Nano by, on average, 20 per cent and 12 per cent respectively. The Nano is closer to the GTX 980 in terms of pure performance, which it beats by 10 per cent on average.

As such, considering the size, there's nothing remotely close to the Nano. It's truly a mini monster, easily capable of handling games at 2,560 x 1,440 and making a surprisingly strong showing at 4K as well. At this resolution, it never drops below 30fps in three of our five games. In The Witcher III, it only passes the technically playable test with a minimum of 27fps, and it takes a game as demanding as Crysis 3 to slow it down to unplayable levels.

In our well-ventilated chassis, the card was always at least 10°C below its thermal cap, but still hovered between 850MHz and 950MHz in games (typically the lower half of this range), indicating a clear power limit. System power consumption barely rose above 300W and the fan only span up to around 35 per cent under sustained load, which was very quiet indeed. Sadly, though, there was clearly audible coil whine with an irritating pitch in every game. Considering the quality of engineering elsewhere, that's a disappointing slip-up.

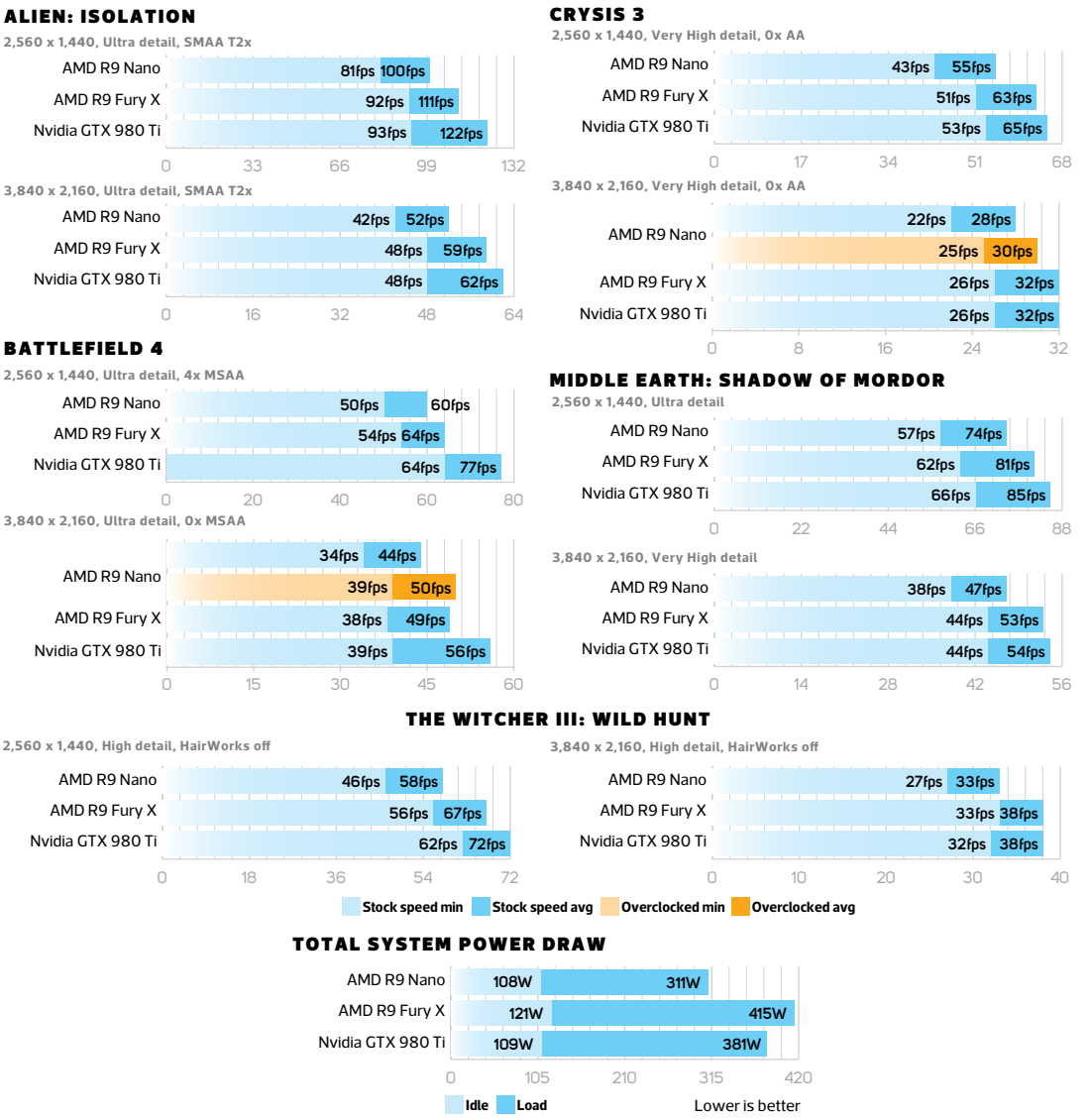
AMD Overdrive lets you increase the power limit by up to 50 per cent. Doing so saw frequencies hover much closer to

1GHz and we managed to add a further 80MHz to the maximum clock. Along with the lifted power limit, these tweaks saw performance increase by anywhere between 7 and 15 per cent. However, the fan was much more audible and the power consumption went up by almost 100W – the Nano isn't really designed for overclocking.

Conclusion

As a feat of engineering, the R9 Nano is amazing. The performance is awesome considering its total volume, and it's cool and quiet too. However, it undoubtedly has niche appeal. Even very compact cases are usually able to house full-length cards such as a GTX 980 Ti, which is faster and costs the same money – the Nano really just buys you a little more cable-routing space. We would say it's a prime candidate for a discreet, 4K lounge gaming PC, but the irritating coil whine and absence of HDMI 2.0 scuppers it here too. The Nano is a cool bit of kit that's sure to find its way into some sweet builds and mods (waterblocks have already been announced), and it's great if you have the money, and want to build the fastest and tidiest mini system possible, such as our feature PC this month (see p84). For most people, though, a short-PCB GTX 970 will offer much better value for money, and even a full-sized GeForce GTX 980 Ti card will fit in most mini-ITX chassis too.

MATTHEW LAMBERT



SPEED 35/40

FEATURES 8/10

VALUE 25/40

EFFICIENCY 7/10

OVERALL SCORE 75%

VERDICT

A seriously cool piece of engineering, with great gaming performance, but it's hampered by some irritating coil whine, and it has a niche target market.

GRAPHICS CARD

Asus GeForce GTX 950 Strix / £139 inc VAT

SUPPLIER www.ebuyer.com

The GeForce GTX 950 slots into Nvidia's stack between the GTX 750 Ti and GTX 960, filling the important sub-£150 price point. Prices start at just under £130 and go up to around £150, meaning the Asus card on test here sits in the middle of the pack, hoping to impress with above average cooling, components and overclocking. Like all the GTX 900-series cards, the GTX 950 uses a second-generation Maxwell GPU – the 28nm GM206. This gives it full DirectX 12 support up to feature level DX12_1.

It uses the same GM206 GPU as the GTX 960, but two of the eight SMMs have been disabled, resulting in a 25 per cent reduction in cores and texture units – 768 and 48 respectively. ROPs aren't tied to the SMMs, so they remain fixed at 32.

Likewise, the memory system is the same. The GPU has an internal L2 cache of 1MB, which is divided into two 512KB partitions, each of which is tied to a 64-bit memory controller. This 128-bit interface is then connected with 2GB of GDDR5 memory. It's a comparatively narrow interface by today's standards, though, which may hurt the GTX 950 in situations that demand high memory bandwidth, such as cranking up the resolution and detail. Nvidia claims it offsets this limit through faster and larger internal caches (1MB is indeed large for L2) to reduce reliance on GDDR5, and through its third-generation delta colour compression engine, a lossless algorithm said to reduce the bytes needed per frame by 25 per cent on average.

Reference clock speeds are set at 1024MHz base (1188MHz boost) and 6.6GHz effective for the memory. Asus also applies a pleasing 14 per cent overclock to the core – 1165MHz base (1355MHz boost) – but the memory runs at the same speed.

The GTX 950 also adopts the GTX 960's new video engine, which brings full hardware support for H.265 encode and decode. Up to four 5K monitors can be run at once and HDMI 2 is supported for 4K 60 content. Naturally, G-Sync is available via the DisplayPort output, while a pair of dual-link DVI ports and a single SLI connector round off the collection of connectors.

Nvidia is also debuting its MOBA input latency reduction feature with the GTX 950, although it will come to other existing cards in the future too. It works by cutting the number of pre-rendered frames in the DirectX pipeline from two to one, and is available as an option in GeForce experience for DOTA 2, Heroes of the Storm and League of Legends. Nvidia claims to have reduced latency in DOTA 2 by nearly 50 per cent compared with a GTX 650.

With a 90W reference TDP, power requirements are low enough for a single 6-pin PCI-E power connector, which Asus uses, along with a 4+1 phase power configuration with Super Alloy Power components; Asus claims this will bolster efficiency and overclocking potential.

The cooler utilises two direct-contact heatpipes connected to a single fin stack, and it's cooled by two temperature-controlled fans that switch off entirely when the GPU temperature is below about 60°C. It's a basic design that doesn't offer direct cooling to the memory or VRMs, but that's not an issue at this level of performance.

Performance

A brief look at average frame rates puts a stock-speed GTX 960 at 8 per cent quicker than the GTX 950 Strix overall, while an Asus R9 380 Strix is roughly 20 per cent ahead. Examine the all important minimums, though, and the GTX 950 Strix is clearly a very capable 1080p GPU, able to churn out playable frame rates in modern games with practically all the settings turned up.

With a few sacrifices here and there, you could achieve very smooth gameplay – in the less demanding Alien: Isolation, for example, it managed a super-smooth 60fps minimum, and that's at full detail. The one exception is Shadow of Mordor, but even then it managed 28fps, passing our technically playable test. However, 2,560 x 1,440 gaming proved too much for the GTX 950 – it only offered a playable frame rate in Alien: Isolation at this resolution.

Meanwhile, efficiency is excellent, as always with Maxwell GPUs. Our system power consumption peaked at a little over 200W, so the already quiet cooler has an easy job – even when the fans did spin up, they were inaudible.

Overclocking proved fruitful too. We added 100MHz to the base clock, taking it to 1265MHz, whereby the actual

/SPECIFICATIONS

Graphics processor Nvidia GeForce GTX 950, 1165MHz (boost 1355MHz)

Pipeline 768 stream processors, 32 ROPs

Memory 2GB GDDR5, 6.6GHz effective

Bandwidth 105.6GB/sec

Compatibility DirectX 12, OpenGL 4.5

Outputs / inputs DisplayPort, Dual-link DVI-D, Dual-link DVI-I, HDMI

Power connections 1 x 6-pin, top-mounted

Size 220mm long, dual-slot

ELITE
NEW ENTRY
P62

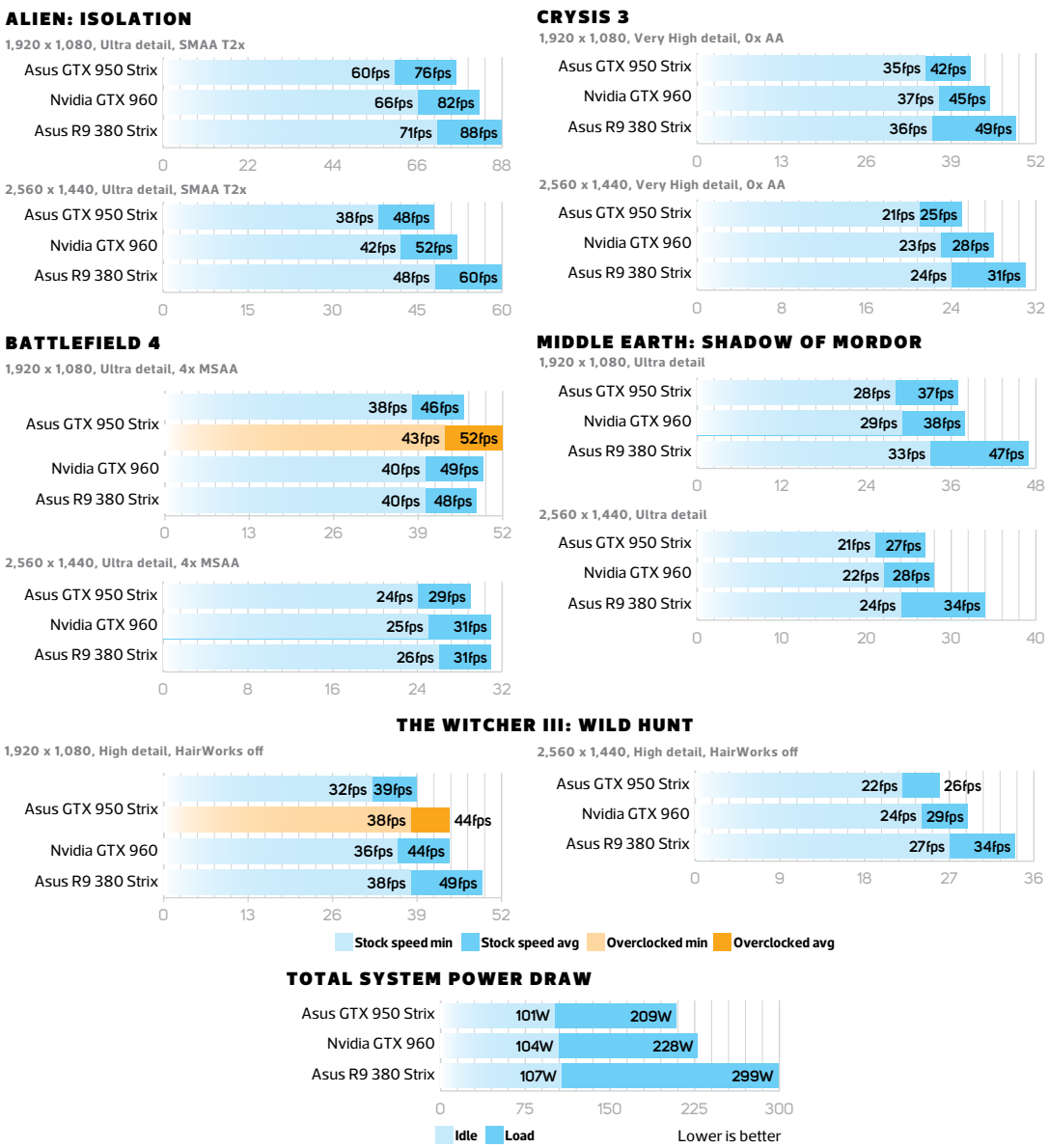
in-game frequency was around 1.5GHz. We also kept the memory stable at 8.2GHz (effective), a whopping 24 per cent increase over stock speeds. In this state, the card remained quiet and it was able to surpass GTX 960 and R9 380 performance, but only just.

Conclusion

There's no doubt that this Asus Strix model is an outstanding GTX 950 card. It has a big overclock out of the box, it's capable of significantly higher clocks still and it will be inaudible in almost any setup. With these credentials, and its modernised video engine, the GTX 950 Strix would be great for use in a discreet HTPC or a mini 1080p gaming rig.

Its only problem is that there are faster GeForce GTX 960 cards available for not much more money, but these cards still won't get you much more in terms of playable frame rates, and the extra premium gets you very quiet operation and great overclocking headroom too. The Asus GeForce GTX 950 Strix might be a little overpriced for the performance on offer, but it's still a highly efficient, quiet and overclockable card for 1080p gaming.

MATTHEW LAMBERT



SPEED 28/40 | FEATURES 8/10

VALUE 34/40 | EFFICIENCY 9/10

OVERALL SCORE 79%

VERDICT

Very quiet, overclockable and highly efficient. The Asus GeForce GTX 950 Strix is a great sub-£150 card for 1080p gaming.

PC Specialist recommends Windows 8.1

Performance without compromise

Trion 960

- Overclocked Intel® Core™ i5-4690K
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GRAPHICS CARD

EVGA GeForce GTX 980 Ti Classified ACX 2.0+ / £619 inc VAT

SUPPLIER www.scan.co.uk

EVGA has ten GTX 980 Ti cards in its roster, and the Classified sits at the top, at least until the K|NGP|N edition is released. With a price of £620 inc VAT, however, it needs to prove itself.

It's based on Nvidia's GeForce GTX 980 Ti GPU, which sports 2,816 cores, 176 texture units and 96 ROPs, and it's paired with 6GB of GDDR5 via a 384-bit memory bus, which equips it with enough horsepower for 4K gaming. However, EVGA has overclocked the core by a massive 19 per cent, taking it to a base cock of 1190MHz (1291MHz boost), with actual speeds of over 1400MHz observed in games. It's one of the highest factory overclocks around for this GPU, but the memory has been left at 7GHz (effective). We've had great success overclocking the memory used with the GTX 900 series, so this is a little disappointing.

The fans switch off when the GPU temperature is below 60-65°C

The Classified sports the standard set of display outputs, and it's also fitted with dual SLI fingers, with 4-way setups supported. It maintains a dual-slot form factor and its length measures just under 280mm, making it an easy fit in most cases. That said, the cooler does extend past the expansion slot bracket edge by almost 30mm, which could affect some small form factor chassis.

Meanwhile, EVGA's ACX 2.0+ cooler is very well built and uses six heatpipes and a GPU contact plate, all of which are nickel plated. A cooling plate also ensures all the memory chips and VRMs are directly cooled by the two fans, which each feature optimised swept fan blades, double ball bearings and an extreme low power motor. EVGA claims this combination improves airflow while reducing noise, but also decreases fan-power consumption, leaving more power available for the core components when overclocking. The fans are semi-passive too, switching off completely when the GPU temperature is below 60~65°C. Lastly, while there's plenty of ventilation in the rear I/O panel, the cooler shroud is open at the sides, so bear in mind that lots of heat will end up in your chassis.

The card is also supported against its own weight by a brushed metal backplate, which has the added benefit of looking rather swish through a case window, and it will help a little with heat dissipation too.

Power is drawn through a pair of 8-pin PCI-E connections (an upgrade from the reference 8-pin/6-pin combo) and two dual 6-pin to single 8-pin adaptors are provided as well, each neatly braided in black.

Power delivery, meanwhile, is handled by a massive 14+3 power phase setup – the main reason for the extended PCB height. In theory, this setup will help to deliver higher levels of clean power to both the core and memory than the standard 6+2 design, which can be useful when overclocking.

Other features include support for EVBot, EVGA's dedicated hardware controller for overclocking on the fly, via a dedicated connection next to the power inputs. You'll also find a BIOS switch here – the card has one marked normal and another marked for liquid nitrogen cooling. Lastly, you get easily accessible voltage monitoring points next to the BIOS switch (although no cables to connect to them) and a non-conductive thermal strip to place over the VRMs and prevent shorting when using aftermarket cooling – EVGA has clearly kept extreme overclockers in mind when designing the Classified.

Performance

Average frame rates tell us that this card is approximately 14 per cent quicker than a stock GTX 980 Ti. Compared with AMD's flagship, the R9 Fury X, it's 23 per cent quicker at 2,560 x 1,440 and 'only' 19 per cent ahead at 4K.

The all-important minimum frame rates tell us that this card makes light work of 2,560 x 1,440, staying above 60fps in every test – an achievement that neither the Fury X nor a stock-speed GTX 980 Ti can match. Even at 4K, frame rates are consistently smooth - the lowest result is 31fps in Crysis 3. The 30-60fps margin is where G-Sync really shows its capabilities, so this card would be great with 4K G-Sync screen. In short, the GTX 980 Ti Classified effectively represents the pinnacle of current single GPU performance.

Power consumption is higher than a GTX 980 Ti by around 50W under load, but the total system peak draw is still comfortably below 430W. The ACX 2.0+ cooler does an admirable job too. It kept the GPU at a delta T of under 60°C in a well-ventilated chassis, with the fans peaking at around 1,400rpm, which proved to be only just audible. There was also zero coil whine; indicative of high-quality components.

/SPECIFICATIONS

Graphics processor Nvidia GeForce GTX 980 Ti, 1190MHz (boost 1291MHz)

Pipeline 2,816 stream processors, 96 ROPs

Memory 6GB GDDR5, 7GHz effective

Bandwidth 336GB/sec

Compatibility DirectX 12, OpenGL 4.5

Outputs/inputs 3 x DisplayPort, Dual-link DVI-I, HDMI

Power connections 2 x 8-pin, top-mounted

Size 279mm long, dual-slot

ELITE
NEW ENTRY
P62

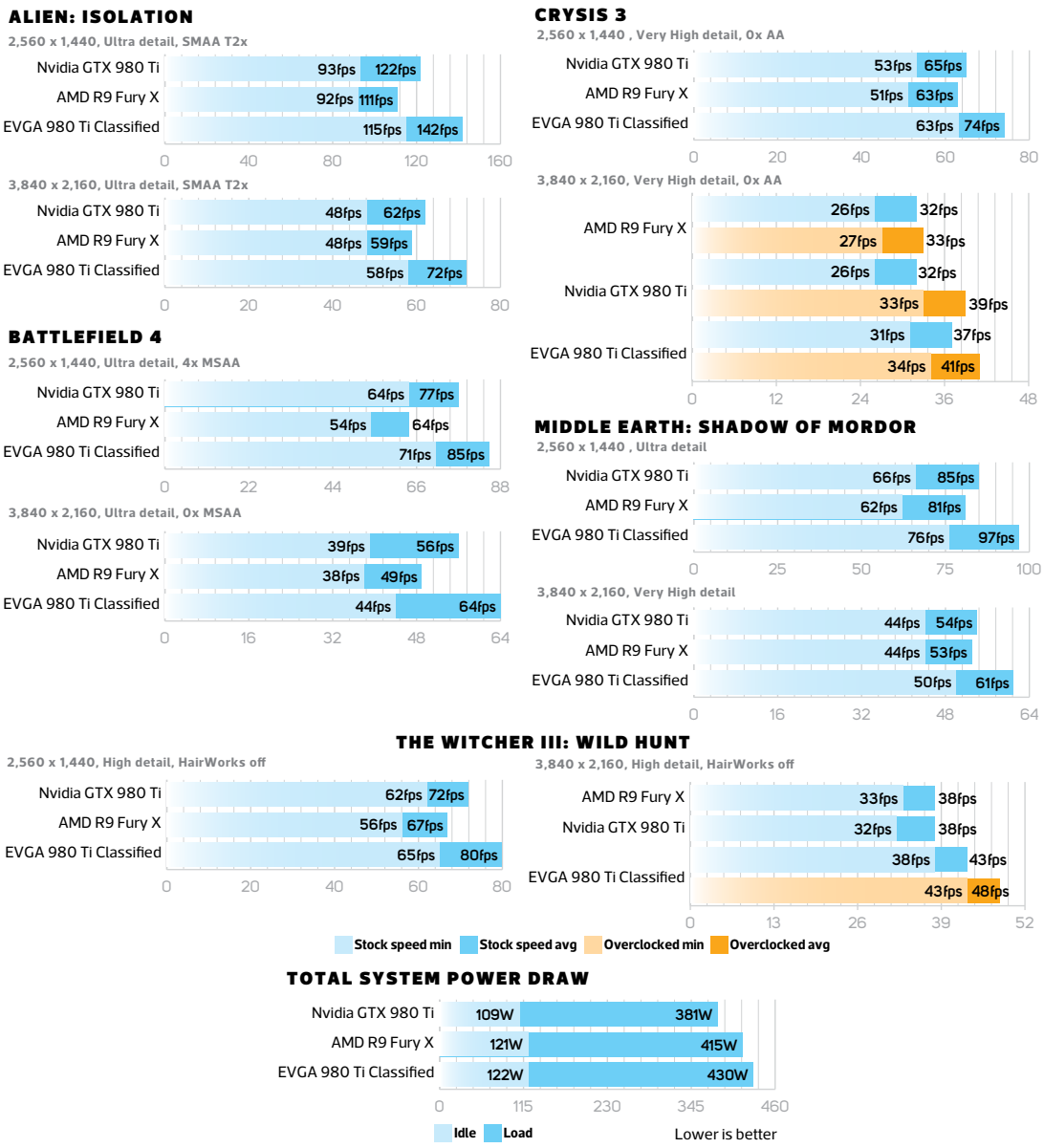
We used EVGA Precision X to max out the power and thermal limits and increased the GPU voltage by 50mV too. We managed to add 75MHz for a 1265MHz base clock (1366MHz boost). In reality, though, the card was staying at over 1.5GHz under load – a truly outstanding result for this GPU. The memory reached a staggering 8.4GHz (effective) as well.

These impressive overclocks yielded performance increases of between 7 and 13 per cent, with a trade-off of slightly elevated power consumption, temperature and noise, although nothing alarming in any case.

Conclusion

Pairing a GTX 980 Ti with a 19 per cent overclock results in performance that's simply through the roof, and the EVGA GeForce GTX 980 Ti Classified ACX 2.0+ even has a fair bit of overclocking headroom left in the bank. All the bells and whistles are there too; even those who like to dabble with liquid nitrogen are covered. Yes, the price tag is around £100 more than a standard GTX 980 Ti, but if you truly want to play games smoothly at 4K with a single GPU, this sort of investment is needed.

MATTHEW LAMBERT



SPEED	FEATURES
40/40	9/10
VALUE	**EFFICIENCY**
26/40	7/10

OVERALL SCORE
82%

VERDICT

An outstanding and very desirable graphics card that's capable of smooth, high-detail 4K gaming on a single card.

MINI-ITX MOTHERBOARD

Asus Z170i Pro Gaming / £130 inc VAT

SUPPLIER www.cclonline.com

Our Z170 motherboard Labs this month (see p38) looks at full-sized motherboards for Intel's Skylake CPUs, but there are still limited numbers of mini-ITX Z170 boards. All is not lost, though, as Asus' Z170i Pro Gaming has just landed in our lab. We're expecting a bunch of new mini-ITX offerings to land in the next few weeks as well, from Gigabyte, MSI and ASRock, as well as the highly anticipated Maximus VIII Impact from Asus. For now, though, the Z170i Pro Gaming is one of few options available if you're looking to build a mini-ITX Skylake system.

Asus has also changed its mini-ITX line-up with the launch of Z170, and rather than including a mainstream board along with a pricier ROG Impact board, which has been its strategy since the original Impact launched on the Z87 chipset, the company's cheaper offering now comes under the Pro Gaming banner, with a distinctly snazzy look and feel.

The M.2 port is on the underside to save space

That's a bit of a shame, as the P8Z77-I Deluxe and Z97I-Plus looked both smart and distinctive, while the Z170i Pro Gaming looks very like the early shots of similar boards we've seen from MSI and Gigabyte. Thankfully, the Z170i makes up for its lack of unique aesthetics with features.

The PCB is crammed full of ports and headers, although the first obvious omissions are on-board overclocking and testing tools, such as power and reset buttons or an LED POST code display. That said, few (if any) of Asus' mainstream mini-ITX boards had these features.

Otherwise, there's plenty to talk about. There are three fan headers – two for the CPU and one for a system fan, although there's no dedicated all-in-one liquid cooler pump header as we've seen on several of Asus' full-sized boards. There's a single SATA Express connector at the edge of the PCB, including two SATA 6Gbps ports, but the other two SATA 6Gbps ports are located on the other side of the DIMM slots, which could make tidy cable routing tricky. The fan headers, USB 3 header and front panel connectors are all well-placed though.

Meanwhile, an M.2 port is located the port on the underside of the PCB to save space – a trick Asus implemented with the Z170i Pro Gaming's predecessor – and the port is compatible with SSDs up to 80mm in length. The downside, of course, is that you need to remove the motherboard to access it.

On the top of the board are three heatsinks, all of which are fairly small, including the ones surrounding the CPU socket, so large air coolers should have no compatibility issues. Asus has even squeezed in a small section of isolated audio circuitry for the Realtek-based SupremeFX audio codec, which sports a headphone amplifier. There's also an integrated 802.11ac Wi-Fi module, which has rear connectors for use with the included desktop magnetic antenna.

Finally, the rear panel sports more USB ports than we've seen on some full-sized Z170 boards, although there's no Type-C USB 3.1 port – only two Type-A USB 3.1 (Gen 2) ports are included, which are backwards compatible with previous USB standards. There's a bank of four USB 3 ports plus two USB 2 ports too, so if your setup is USB-heavy, the Z170i Pro Gaming is certainly up to the task.

Performance

We've come to expect exactly the same performance from mini-ITX motherboards as their larger counterparts, and Z170i Pro Gaming generally doesn't disappoint. The M.2 port managed read and write speeds of 1,556MB/sec and 669MB/sec respectively using our HyperX Predator SSD – easily as fast as any other board we've tested, and the same was true for the SATA 6Gbps ports' 563MB/sec read and 531MB/sec write speeds.

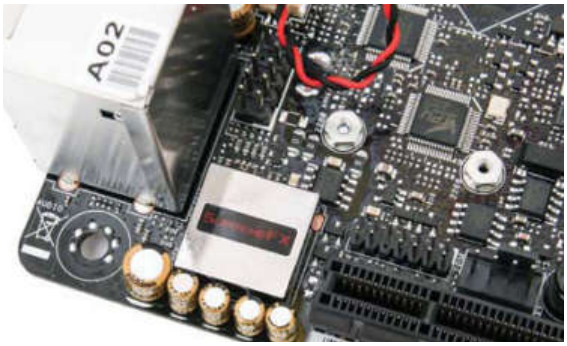
In our game benchmark, Total War, it also matched the result of its bigger sibling, the Hero, with a minimum frame rate of 58fps, while its total system score of 132,454 is roughly in the middle of the pack, thanks to a slightly lacklustre image editing result. The audio performance was practically identical to that we've seen on Asus' ROG boards too, with dynamic range and noise levels around the 104dBA and -104dBA respectively – results that are very good for on-board audio.

The Z170i proved to be a capable overclocker as well, and the EFI is surprisingly ROG-like in layout and feel, although several ROG EFI features, such as SSD secure erase, are absent. It managed to overclock our Core i7-6700K to 4.8GHz with ease, needing just 1.32V to get there. Sadly,

/SPECIFICATIONS

Chipset Intel Z170
CPU socket Intel LGA1151
Memory support 2 slots: max 32GB DDR3 (up to 3400MHz OC)
Expansion slots One 16x PCI-E 3
Sound Asus SupremeFX
Networking Intel Gigabit LAN
Overclocking Base clock 40–500MHz, CPU multiplier 8–83x; max voltages CPU 1.7V RAM 1.8V
Ports 4 x SATA 6Gbps (Z170), 1 x SATA Express, 1 x M.2 (2280), 2 x USB 2, 4 x USB 3, 2 x USB 3.1 Type-A, 1 x LAN, 6 x surround audio out, line in, mic, optical S/PDIF out, 1 x HDMI, 1 x DisplayPort
Dimensions (mm) 170 x 170

ELITE
NEW ENTRY
P62



4.9GHz was a little too far, with neither a 1.48V vcore nor maximum loadline calibration getting a stable result. Even so, the 4.8GHz frequency saw the system score rise from 132,454 to a healthy 147,915. Power consumption rose thanks to the overclock, but the idle total system power draw only increased from 49W to 60W, with load power consumption rising to 166W from 135W.

1 **The 802.11ac Wi-Fi module has rear connectors for use with the included desktop magnetic antenna**

2 **The heatsinks are all fairly small, so you shouldn't have any compatibility issues with large CPU coolers**

3 **There are three fan headers – two for the CPU and one for a system fan**

Conclusion

The Z170i Pro Gaming continues Asus' excellent run of pedigree enthusiast mini-ITX motherboards that nearly match their larger siblings in terms of performance and overclocking. It also has excellent on-board audio, and can handle the latest high speed interface standards.

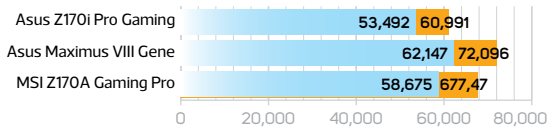
We've yet to compare it with the competition directly, but early indications are that it's favourably priced and well featured, so we have no hesitation in recommending it for small form factor builds.

The only motherboard likely to beat it in terms of enthusiast features is Asus' own Maximus VIII Impact, but it will also cost considerably more. In the meantime, the Asus Z170i Pro Gaming provides a great foundation for a mini mainstream Skylake build.

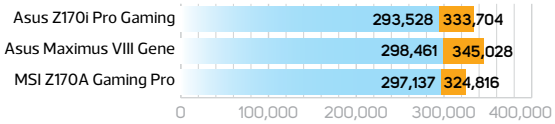
ANTONY LEATHER

CPC MEDIA REALBENCH 2015

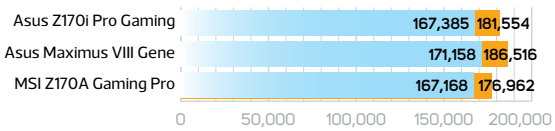
GIMP IMAGE EDITING



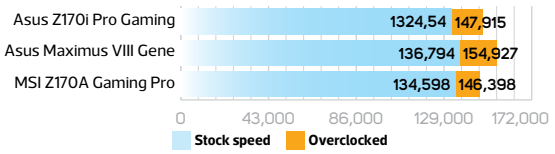
HANDBRAKE H.264 VIDEO ENCODING



HEAVY MULTI-TASKING

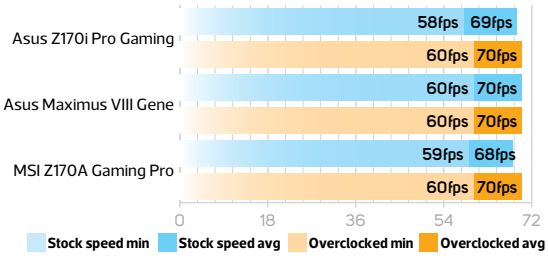


SYSTEM SCORE

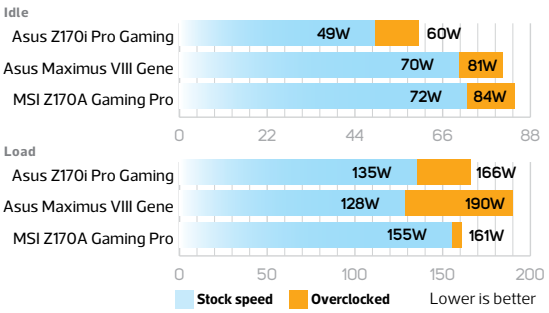


TOTAL WAR: ATTILA

1,920 x 1,080 0x AA Quality setting



TOTAL SYSTEM POWER CONSUMPTION



SPEED **36/40** | FEATURES **22/30**

VALUE **26/30**

OVERALL SCORE **84%**

VERDICT

A competent overclocker with loads of features for a reasonable price – a great foundation for a mini Skylake build.

/TEST KIT

4GHz Intel Core i7-6700K, 16GB Corsair Vengeance LPX DDR4 2666MHz DDR3 memory, 256GB OCZ Arc 100 SSD, Corsair HX860i PSU, Windows 10 Home 64-bit

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WIN! A be quiet! Silent Base 600 case

IN THE COLOUR OF YOUR CHOICE

German manufacturer be quiet! is famous for making some of the most technologically advanced and quietest PC equipment available. The company's latest PC case, the Silent Base 600, offers the perfect symbiosis of noise prevention and cooling ability, as well as good usability and an extensive capacity for high-end hardware.

The combination of innovative construction and two pre-installed Pure Wings 2 fans assures that cooling ability and air circulation are excellent, and you can control the airflow too. Meanwhile, numerous sound-insulation features, such as the double-glazed window, contribute to the case's whisper-quiet operation.

In addition, the case's use of tool-free mounts, as well as its generous space for hardware and cable management, means it offers first-class usability. The end result is a case that's ideal not only for high-end gaming gear, but also for quiet systems.

The new case is available in six versions, with a choice of three accent colours – orange, black and silver – and the option for a window. What's more, be quiet! is offering the winner of this competition a Silent Base 600 in their own choice of colour, with or without a window. To be in with a chance of winning a Silent Base 600 case, answer the question below.

QUESTION: Which accent colour is not available for the Silent Base 800?

A. Orange
B. Silver
C. Green

Email your answer to competition@custompcmag.org.uk, with 'be quiet! Competition 147' in the Subject line.
Closing date 19 November, 2015. See www.dennis.co.uk/comp/terms for the full competition rules.

GAMING KEYBOARD

CM Storm Quick Fire XTi / **£140** inc VAT (MSRP)

SUPPLIER TBC

Most keyboards with complicated macro and lighting customisation options manage these features through software. There are a few exceptions, however, and adding itself to that list is CM Storm's Quick Fire XTi. This new keyboard offers multi-colour per-key backlighting, five on-board profiles and programmable macros for almost every key, yet it's also fully plug-and-play with no need for software.

The Quick Fire XTi has an extremely minimalist design; it's about as small as possible for a full 105-key keyboard. The small space above the numeric keypad is home to four dedicated profile keys, allowing for easy switching at any time. You can also hit FN-Esc to go to the keyboard's default profile, which returns every key to its default function.

> There's a lovely glow between the keys

All five profiles, including the default one, can have a wide array of backlighting effects applied. Using FN-F3, you can flick between pre-programmed effects that are applied to the entire key set, or, with FN-Pause, record your own per-key patterns. Each key is backed by a dual-colour LED. FN-F2 controls the red lighting while F1 controls blue lighting, and you can also achieve a purple effect. There are five levels of brightness per colour, which equates to 35 possible combinations overall. In record mode, the FN key indicates the current selected colour, and you then simply hit which keys you want to be that colour. It may sound confusing, but you quickly get used to it, and Cooler Master has made a handy YouTube manual to guide you through the process.

The quality of the lighting is superb. The brightness is consistent, the colours are solid and there's a lovely glow between the keys courtesy of the white plate on which the keys rest. This plate also helps to spread the light effectively through dual-symbol keys.

Meanwhile, macros can be recorded and stored in all but the default profile using FN-F9 (F10 for macro deletion). Most keys are available for programming, with the available (empty) ones lighting up blue. Once a key is selected, you simply enter your keystrokes – the keyboard can handle at least 100 key presses per macro and there's no obvious time limit either. You can even set specific playback modes for the macro – one-time, toggle or loop.

Of course, without software, there are limitations as to what can be achieved. For example, the backlighting isn't RGB, although red, blue and purple are popular colours among many enthusiasts. You also can't program keys with functions, such as Windows or program shortcuts, nor can you set macros to be replayed without delays – these settings are stored and played in real time.

All this customisation would be meaningless if the keyboard itself wasn't up to scratch, but thankfully, the Quick Fire XTi is fantastic. It's extremely well built, and feels as solid and robust as the best keyboards we've used. The rubber pads equip it with a strong grip on smooth surfaces, while its rear legs provide a sharper typing angle if desired. The USB cable is detachable too, which typically increases longevity, and it can be threaded through one of the underside's three cable channels to keep your desk tidy.

Our sample was furnished with a full set of Cherry MX Brown switches, although Red and Blue Cherry MX options are also available. In use, the switches are as excellent and consistent as ever. We find the light, tactile Brown switches to be pleasant both in typing and when gaming, making them ideal for people who do lots of both on the same machine. Full 105-key rollover is supported over USB and the keycaps are a joy to use, as they're not only smooth, but they also have the right level of grip – they also have a UV

/SPECIFICATIONS

Connection Wired, USB
Cable 1.8m, braided, detachable
Material Plastic
Switch Type Cherry MX Brown (Blue and Red available)
Backlighting Red/blue dual LED, per-key
USB ports None
Wrist rest No
Extras 105-key rollover, Windows lock, media keys, key puller, replacement function key, on-the-fly lighting control, on-the-fly macro recording

coating. Honestly, we can't fault the experience of using the Quick Fire XTi.

While build quality is high, though, extra features are thin on the ground. There's no wrist rest, for example, just a key puller and a replacement keycap sporting the Cooler Master logo. There are also no USB ports or dedicated media controls. The FN key brings a few more functions though. Coupled with F4, it provides a Windows key lock, while F5-F8 control the hardware accelerated repeat rate. Lastly, with the six keys above the arrow keys, you have all the usual media and volume controls at your fingertips.

Conclusion

A price of £140 is serious cash for a keyboard. For those who use their machines solidly, such an investment can make sense, but Cooler Master could still have sweetened the deal with some extra features. If you don't mind using software, Corsair's K70 RGB offers even more lighting and key options, dedicated media keys and a wrist rest, and for £20 less too.

That said, there are very few keyboards that offer multi-coloured lighting control and heaps of macro possibilities without any software – as far as we know, the XTi is the pinnacle of plug-and-play keyboards. These features are very appealing for certain gamers, though, as is the exceptionally high level of quality that Cooler Master has poured into the XTi. If you're looking for a superb mechanical gaming keyboard that's brimming with macro options and doesn't require you to faff around with software, the Quick Fire XTi is currently as good as it gets.

MATTHEW LAMBERT

DESIGN 38/40

FEATURES 28/35

VALUE 15/25

OVERALL SCORE 81%

VERDICT

The Quick Fire XTi offers superb quality and excellent plug-and-play features, which don't require any software. It's expensive, but worth the cost if that's what you're looking for.

How we test

Thorough testing and research is the key to evaluating whether a product is worth buying, and deciding whether or not there's a better alternative

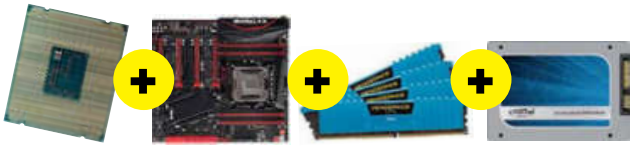
PROCESSORS

We judge CPUs on whether they offer sufficient speed for the price. Part of a CPU's speed score comes from how overclockable it is. Every type of CPU is tested in the same PC, so all results are directly comparable.

INTEL LGA1151

Intel LGA1151 CPU + Asus Z170 Deluxe + 16GB Corsair Vengeance LPX 2666MHz DDR4 + 256GB Samsung 850 Pro

INTEL LGA2011-V3



Intel LGA2011-v3 CPU + Asus Rampage V Extreme + 16GB Corsair Vengeance LPX 2133MHz DDR4 + 512GB Crucial MX100

AMD FM2+

AMD FM2+ APU + MSI A88X-G45Gaming + 16GB Corsair Vengeance Pro 2133MHz DDR3 (GPU testing) + 8GB Corsair Vengeance Pro 1600MHz DDR3 (CPU testing) + 240GB Crucial M500

COMMON COMPONENTS

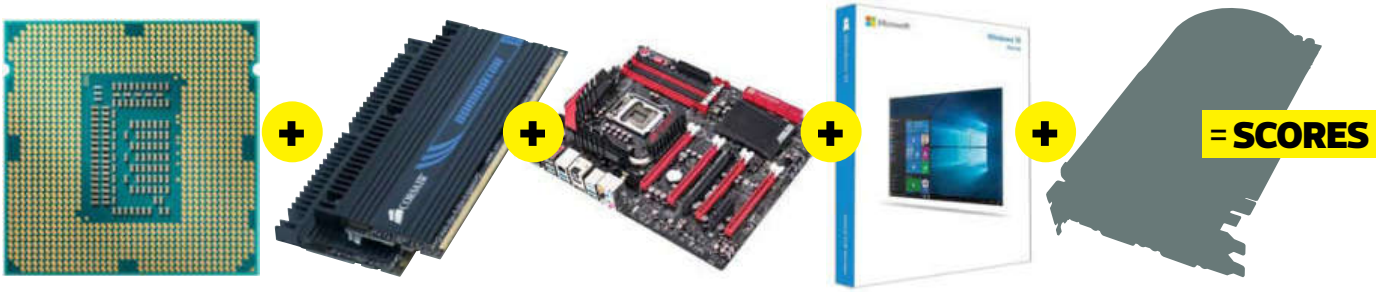
Nvidia GeForce GTX 780 3GB + Windows 10 64-bit

TESTS: We use Custom PC RealBench 2015, Cinebench R11.5 and a variety of games. We also test the power draw of the test PC with the CPU installed. These tests reveal a broad range of performance characteristics, from image editing to gaming and video encoding to 3D rendering. We run all tests at stock speed and again when overclocked to its highest frequency.

*Please note: We test AMD FM2+ APUs using the on-board graphics, not the Nvidia GeForce GTX 780 3GB

GRAPHICS CARDS

Graphics cards are mainly evaluated on how fast they are for their price. However, we also consider the efficacy and quietness of the cooler. Every graphics card is tested in the same PC, so all results are directly comparable.



4.2GHz Intel Core i5-3570K + 8GB Corsair Dominator 2400MHz DDR3 + Asus Maximus V Extreme + Windows 10 64-bit + The graphics card we're reviewing = SCORES

CUSTOM PC REALBENCH 2015

INTEL REFERENCE

Intel Core i7-4790K | 16GB of Corsair 2400MHz DDR3 | 240GB OCZ 150 | Asus Maximus Gene VII | Nvidia GeForce GTX 780 3GB = 100%

AMD REFERENCE

AMD A10-7850K | 8GB of Corsair 2133MHz DDR3 | 256GB Plextor M5 Pro | Asus A88X-Pro = 100%

Our benchmark suite, co-developed with Asus, simulates how people really use PCs – a higher score is better. You can download them from www.asus.com/campaign/Realbench

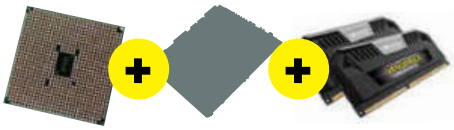
MOTHERBOARDS

Motherboards are evaluated on everything from layout and features to overclockability and value for money. Every motherboard is tested with the same components, so all results are directly comparable.

INTEL LGA1151

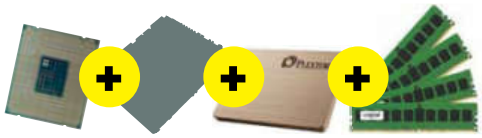
Intel Core i7-6700K | Motherboard on test | 16GB Corsair Vengeance LPX 2666MHz DDR4 | 240GB OCZ Arc 100

AMD FM2+



AMD A10-7870K | Motherboard on test | 16GB Corsair Vengeance Pro 2133MHz DDR3

INTEL LGA2011-V3



Intel Core i7-5960X | Motherboard on test | Plextor M6 256GB | 32GB Crucial 2133MHz DDR4

COMMON COMPONENTS

AMD Radeon R9 390X* | Windows 10 64-bit

TESTS: We use Custom PC RealBench 2015 and Total War: Attila, and also test the speeds of the board's SATA and M.2 ports. We try to overclock every motherboard we review by testing for a maximum QPI, base clock or HTT as well as overclocking the CPU to its maximum air-cooled level. We run our tests at stock speed and with the CPU overclocked.

*Please note: We test AMD FM2+ motherboards using the on-board graphics, not the AMD Radeon R9 390X

TESTS: By using the fast PC detailed on the left, we can be sure that any limitations are due to the graphics card on test, rather than being CPU limited. We test Battlefield 4, Shadow of Mordor, Crysis 3, Alien: Isolation and The Witcher III: Wild Hunt at their maximum detail settings, in their highest DirectX mode, at several resolutions. High-end cards should be able to sustain playable frame rates at 2,560 x 1,440, while 1,920 x 1,080 is more important for mid-range cards; we also test at 3,840 x 2,160 for 4K monitors, and try to overclock every graphics card we test to assess the performance impact.

The Awards

EXTREME ULTRA
Some products are gloriously over the top. These items of excellent overkill earn our Extreme Ultra award.

PREMIUM GRADE
Premium Grade products are utterly desirable – we'd eat nothing but beans until we could afford them.

PROFESSIONAL
Products worthy of the Professional award make you and your business appear even more awesome.

APPROVED
Approved products are those that do a great job for the money; they're the canny purchase for a great PC.

CUSTOM KIT
For those gadgets and gizmos that really impress us, or that we can't live without, there's the Custom Kit award.

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Custom Kit

Paul Goodhead checks out the latest gadgets, gizmos and geek toys

PHONE ACCESSORY

Goggle Cardboard / £15 inc VAT

We're quite taken with Google Cardboard. Its low-fi, home-brew feel appeals to our modding tendencies and it's great being able to assemble a passable VR headset from cardboard. The end experience relies heavily on the smartphone you use to provide the display, however. It needs some grunt to run the games, and the higher the pixel density (ppi) of the screen, the better – a Nexus 6 worked fine in our tests, but an HTC One Mini (M8) struggled, for example.

Gaming on the Cardboard was fun, as was flying around Google Earth, although the effectiveness of the magnetic button on our test model was patchy. The latter has been improved on the newly announced V2, however, so opt for the newer model if you can find it.

●●●●○

SUPPLIER www.amazon.co.uk

SOUNDBAR

Orbitsound A70 AirSOUND Bar / £500 inc ....

Generally, sound bars blast audio straight forwards, and Orbitsound says this state of affairs results in a below-par experience for everyone not lucky enough to be in the central audio sweet spot. Its solution to this problem is the A70, with clever audio processing and an additional pair of end-mounted speakers. It really works too – audio felt much fuller and richer from every angle than with a standard soundbar, with very little variation no matter where we stood. A wireless subwoofer adds bass punch, and with 300W of output, you'll need to wait until the neighbours are out before you push the volume up to full whack.

At £500 inc VAT, it clearly isn't for everyone, but with on-board Bluetooth for streaming music and the ability to pair it with your TV remote, it's a great-quality, feature-rich soundbar if you have the money.

●●●●○

SUPPLIER www.orbitsound.com

EXTERNAL DISK CADDY

Startech S252BU33R / £57 inc VAT

The S252BU33R might not have a catchy name, but it's a cut above your usual external hard drive box, being designed to take two 2.5in disks and run them in RAID 0, RAID 1, JBOD or BIG configurations. It's attractive too, thanks to its anodised aluminium shell, a it's small enough to be portable. The power options can help with portability as well – depending on the power requirements of your drive setup, you can power the box via one or two 5V USB ports for host power, and there's an optional mains adaptor for setups that need more juice, although you'll then be tied to the mains.

A USB 3 port handles data transfer, along with the two SATA 6Gbps ports, but with a JBOD-mode SSD installed, we only measured leisurely read and write speeds of 47.7MB/sec and 34.9MB/sec respectively. While it isn't particularly quick, the S252BU33R still offers an affordable and attractive dual-drive USB box that's ideal if you already have a couple of suitable drives knocking about.

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SUPPLIER www.cclonline.com

CARD GAME

Exploding Kittens: Original Edition / £28 inc VAT

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With over 219,000 Kickstarter backers pledging $8.7m for it, card game Exploding Kittens created a hubbub when it first broke cover in January. It's now on general sale with two decks available – Original and NSFW. The game plays like a cross between Uno and Russian roulette, thanks to a central draw deck that's laced with instant death via the exploding kitten cards. It's simple to pick up and takes just over 15 minutes to play – the aim is to be the last player left unexploded.

Play revolves around using your hand cards to minimise your explosion risk, whether by skipping your turn to draw, or by reshuffling the central deck. It's a fine balance though; while drawing from the deck can be perilous, it's also the only way to replenish your hand.

Exploding Kittens: NSFW Edition / £28 inc VAT

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The card and box artwork is by Matt Inman of The Oatmeal fame and is typically offbeat, lending the game a sense of personality, and the two decks function identically, so it's possible to combine them for bigger games.

Unfortunately, though, some of the adult card images in the NSFW deck are bizarre and their humour often falls flat. It feels half-baked, as if the makers of the game had half a deck of funny card ideas, and then made all the rest up in an alcohol-induced haze. The core game itself is still fun, though, and its shallow learning curve and quick game time makes it a great party or pub game that we heartily recommend.

SUPPLIER www.amazon.co.uk

USB CHARGER

Sandberg USB Master Charger Pro / £78 inc VAT

With ten USB ports, Sandberg claims that the grandly titled Master Charger Pro can meet the charging needs of an entire family. At first glance, ten ports may feel like overkill for the job, but they're soon filled once you factor in two or three devices for each family member. Thankfully, the ports also keep up their high 2.4A output regardless of the number of devices connected, so charging is consistently quick. On the negative side, it has looks that only a mother could love. The logistical challenge posed by tethering so many devices to one small box also shouldn't be underestimated – we were forced to resort to building precarious stacks, which isn't ideal when you're dealing with expensive gadgets.

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SUPPLIER www.morecomputers.com

Seen something worthy of appearing in Custom Kit? Send your suggestions to paul_goodhead@dennis.co.uk

LAB TEST

Mothers of invention

We give 12 motherboards a hammering through our test suite, covering a variety of prices and feature sets, to find the best foundations for new Skylake builds

The performance improvements from Intel's new Skylake CPUs may be more evolutionary than revolutionary, but the new motherboards that accompany them bring interesting changes to the table for high-end gaming PCs. Dual-channel DDR4 memory and optional USB 3.1 are part of the offering, along with 4x PCI-E 3 SSD storage in the slim M.2 form factor, massively improving the bandwidth for M.2 storage over the previous Z97 chipset.

However, there's a huge number of Z170 motherboards from which to choose, with a variety of prices and feature sets. We've already covered some of them, both in our initial Skylake coverage and in a roundup last month, but that's still only scratched the surface of the staggering range on the market. As such, this month we're looking at a far wider range of Z170 ATX motherboards (and a micro-ATX board), putting them through their paces in all our usual tests, looking at the key differences in their design and feature sets, and most importantly, establishing whether they're worth purchasing over the competition.

MATTHEW LAMBERT AND ORESTIS BASTOUNIS

Featured this issue

How we test

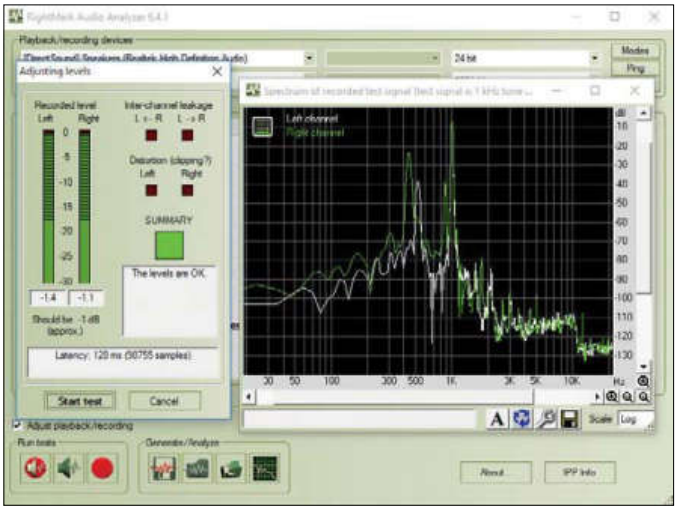
We test each of the motherboards in this Labs test using an Intel Core i7-6700K, the highest-specification LGA1151 CPU currently available. Alongside this CPU is 16GB (2 x 8GB) of Corsair Vengeance LPX DDR4 memory. We also use an OCZ Arc 100 240GB SSD and an XFX Radeon R9 390X Double Dissipation 8GB graphics card. The CPU is cooled using a Corsair H110i GT liquid cooler and the system is powered by an Antec High Current Pro 850W PSU. All tests are performed with Windows 10 Home 64-bit.

We first test each motherboard at its stock settings, resetting the EFI system to its defaults and setting the memory speed to 2666MHz using the built-in XMP profile before booting into Windows. We then attempt to overclock the board to its highest possible CPU frequency. The maximum clock frequency we've achieved with our sample is 4.9GHz. Beyond this clock speed, the voltage needed for stability would necessitate venturing into extreme cooling, so this speed is the realistic limit of the chip.

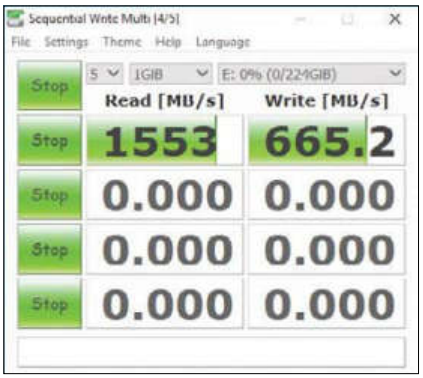
For simplicity's sake, we leave the base clock at 100MHz and tweak the multiplier and vcore until we reach the maximum possible frequency with the lowest possible voltage to achieve it. We also disable CPU power-saving features and set loadline calibration (or the equivalent setting) to its maximum, as this tweak has proved useful when overclocking Skylake CPUs. Once a stable overclock is found, we repeat the CPU-based tests.

We've tested using the latest version of Custom PC RealBench 2015 (see p112). This benchmark runs four separate tests, taxing a PC's single-threaded performance using the Gimp image manipulation suite, heavily multi-threaded performance using the Handbrake open source video transcoder, OpenCL performance using LuxMark and heavy multi-tasking performance by playing back full-screen HD video at the same time as conducting a video transcode. We've excluded the OpenCL results from this test, as it only really tests graphics card performance.

Each test produces an individual point score based on completion time, and also outputs a weighted system score. The entire suite is free to download so you can easily run it on your home system and see how your hardware compares to the kit on test.



On-board audio performance is tested using Rightmark Audio Analyzer



We use CrystalDiskMark test the chipset's SATA 6Gbps speed, and the speed of any M.2 ports

Gaming performance is assessed using the built-in Londinium benchmark in Total War: Attila

To test in-game performance, we use the built-in Londinium benchmark in Total War: Attila, capturing the minimum and average frame rate over the first 50 seconds using Fraps. The test is performed at 1,920 x 1,080 with Quality settings and anti-aliasing disabled. While the test is partially GPU-limited, this game also heavily taxes the CPU, so the onus is still on the motherboard to perform.

Next, we use CrystalDiskMark to test the chipset's SATA 6Gbps speeds as well as the speeds of any M.2 ports using a Samsung SSD 850 PRO 256GB and a Kingston HyperX Predator 240GB M.2 PCI-E SSD respectively.

We then test on-board audio using Rightmark Audio Analyzer. With a 3.5mm audio cable, we connect the line-out jack to the line-in jack, and then set both devices to 24-bit/96kHz in the Windows Properties menu. We then run the Playback/Recording test at these settings, adjusting the levels to as close to -2dB as possible. The results we report are noise level, dynamic range and total harmonic distortion.

Last but not least, we record idle power consumption as well as load consumption using Prime95's smallfft test, both at stock settings and when overclocked.

USB STANDARDS

The USB Implementers Forum (USB-IF) has recently caused confusion by making the new USB 3.1 spec essentially absorb the older USB 3.0 one. The ports we all know as USB 3.0 (5Gb/sec maximum transfer speed) are now officially called USB 3.1 Gen 1, while new 'real' USB 3.1 ports (10Gb/sec) are USB 3.1 Gen 2. We'll be sticking to USB 3.0 and USB 3.1 for simplicity, but if you see either of the new names listed in motherboard spec sheets, that's why!

ASRock Fatal1ty Z170 Gaming K4 / £108 inc VAT

SUPPLIER www.kikatek.com

The two ASRock motherboards in this test join Gigabyte's Z170XP-SLI in the sub-£110 family, making them among the cheapest boards on test. The first noticeable aspect of the Z170 Gaming K4 is its two PCI-E 16x slots, rather than the three slots found on many other boards this month. Although most people won't install more than two graphics cards, if you do have a CrossFire configuration, there won't be any room for a 4x card such as a PCI-E SSD.

However, the leftover space from only having two 16x slots isn't wasted. There are three PCI-E 1x slots, but as long as you stick to dual-height graphics cards, there's extra room for airflow underneath each of them and still space to fit a shorter card in each PCI-E 1x slot, which is good to see.

The Gaming K4's layout is generally good in other respects too. There's plenty of space around the power connectors, and although the SATA ports aren't right-angled, they've been positioned so they can't get in the way of long graphics cards in the lower slot. It's not all good news though. The sizeable heatsinks on the VRMs have no heatpipe, and the fan headers are tightly packed together as well. Meanwhile, the separate PCI-E Molex power connector is in the middle of the board, where it's pretty difficult to access and, as on some other boards, the M.2 slot will also be obscured by the top graphics card.

Meanwhile, ASRock's EFI generally matches the efforts of other manufacturers in terms of layout and features. The initial splash screen shows the usual information, such as temperatures and boot priority, and there's a link to ASRock's EZ OC feature for quick and easy overclocking, plus firmware updating via either USB or online sources.

Switch to the EFI's advanced mode and you get a tab system that's easy to navigate, with the usual way to add frequently accessed settings to a Favorites bar, while voltages are in separate submenus, although Gigabyte's EFI offers more voltage options. As with MSI's EFI, you get a handy system browser, which is useful if you suspect one of your components isn't working properly. It looks good too, with a high contrast colour scheme and font. Notably, despite the entry-level purchase price, the Z170 Gaming K4 supports an impressive maximum memory frequency of 3866MHz, more than some of the more expensive boards, although this is a niche feature. The Gaming K4 was also capable of an overclocked and stable 4.8GHz clock frequency without thermal throttling, though it required 1.48V to be passed through it.

However, while the Fatal1ty Z170 Gaming K4 is clearly a well-built, good-value board, its performance, while still quick enough, was still slower comparatively slow, with the lowest result in our image editing test. Perhaps more importantly, though, ASRock's own Extreme4 costs a similar amount of money, yet offers a third 16x PCI-E slot, along with on-board power and reset buttons, a POST code display, a clear-CMOS switch and SLI support, all of which are strangely absent on the Fatal1ty Z170 Gaming K4.

Conclusion

The ASRock Fatal1ty Z170 Gaming K4 is a decent Z170 motherboard for the money, but ASRock has missed a few tricks with its feature set, such as on-board power and reset buttons. What's more, ASRock's own Extreme4 motherboard offers more features, including a third PCI-E slot, as well as quicker performance, for a similar price, making it a superior budget buy.

PERFORMANCE 26/30

FEATURES 24/35

VALUE 30/35

OVERALL SCORE 80%

VERDICT

A decent Z170 motherboard, but ASRock's Extreme4 offers a wider feature set and quicker performance for a similar price.

/SPECIFICATIONS

Chipset Intel Z170

CPU socket Intel LGA1151

Memory support 4 slots, max 64GB DDR4 (3866MHz - OC)

Expansion slots Two 16x PCI-E, three 1x PCI-E

Sound Realtek ALC1150

Networking Killer E2400 Gigabit LAN

Overclocking Base clock 100–340MHz, CPU multiplier 8–120x; max voltages, CPU 1.520V, RAM 1.8V

Ports 1x PS/2, 2 x SATA Express, 6 x SATA 6Gbps 1x M.2, 2 x USB 2, 5 x USB 3, 1x USB 3 Type C, 1x Gigabit LAN, 8-channel surround audio out, line in, mic, optical, S/PDIF out

IGP display outputs 1x DVI, 1x HDMI

Dimensions (mm) 305 x 244

ASRock Z170 Extreme4 / £109 inc VAT

SUPPLIER www.scan.co.uk

ASRock's two motherboards on test are very close in price and, if you ignore the branding and red colour scheme of the Fatal1ty Z170 Gaming K4, the components look very similar to those on the Z170 Extreme K4. The cover for the I/O shield and audio hardware is identical, just painted a different colour, and the heatsink design for the VRMs is pretty much the same too.

The Extreme 4 improves on the Fatal1ty in a few ways though. There are still six 6Gbps SATA ports and three SATA Express ports, but the larger block of them to the right of the board are right-angled, solving the potential problem of long video cards being obstructed. There's another 16x PCI-E slot too, raising the total from two to three, and the Extreme4 also supports SLI as well as CrossFire.

There's an extra gap for airflow underneath the top 16x slot too, although the M.2 connector is positioned right underneath it, guaranteeing that it will be obscured by a dual-slot graphics card cooler. There's sensible spacing for dual-slot coolers in the other 16x slots too, although you'll then end up blocking two of the three 1x PCI-E slots. Space around the connectors is generally ample, with plenty of space for the 8-pin CPU connector and fan headers at the top. The board is quite crowded in the bottom right, though, with SATA ports, power and reset buttons and an error code display. The display and buttons are welcome inclusions that are absent on the Fatal1ty board, but they could be better positioned – there will be cables all over the place in this area in an assembled PC.

We're surprised that, even with the modern Z170 chipset, USB 3 hasn't completely replaced USB 2 as the standard used throughout motherboard designs, but the Extreme4 is one of the few boards on test that thankfully banishes the older standard from the rear I/O panel, so you won't need to fumble around the back, wondering if your hard disk is plugged into the right port. USB 3.1 is present too, in type-A and type-C forms, bringing the total number of rear USB ports to eight. Rounding off the rear I/O panel is a range of video outputs for the IGP, should you need it, including DVI, HDMI and DisplayPort connectors.

As expected, ASRock has used a similar EFI on both the Extreme 4 and Fatal1ty Z170 Gaming K4, albeit with slightly different colours. The Fatal1ty EFI is red, while the Extreme4 EFI has a blue scheme. The menus and settings are otherwise the same, although you get a few more overclocking options with the Extreme4. ASRock's EFI design is generally very good, with a concise menu system, clear labelling and a good range of features that matches other board makers.

We were pleased to see the Extreme4 perform well with overclocking too, managing a stable 4.8GHz frequency at 1.48V, matching the results from the Gaming K4. Higher speeds weren't possible, and the voltage is pretty high, but it's a good achievement from one of the cheapest boards on test. The Extreme4 was no slouch in performance either, achieving the fourth best RealBench 2015 overall system score on test.

Conclusion

The ASRock Extreme4 has a strong board layout, a wide range of features, a well-designed EFI and good potential for overclocking. Best of all, it only costs £109 inc VAT, making it a great foundation for a budget Skylake build.

PERFORMANCE 27/30

FEATURES 27/35

VALUE 32/35

OVERALL SCORE 86%

VERDICT

Solid performance, loads of enthusiast features and surprisingly good overclocking abilities make the Extreme4 a great motherboard if you're on a tight budget.

/SPECIFICATIONS

Chipset Intel Z170

CPU socket Intel LGA1151

Memory support 4 slots, max 64GB DDR4 (3866MHz - OC)

Expansion slots Three 16x PCI-E, four 1x PCI-E

Sound Realtek ALC1150

Networking Intel Gigabit LAN

Overclocking Base clock 90–600MHz, CPU Multiplier 8–120x; max voltages, CPU 1.520V, RAM 1.8V

Ports 3 x SATA Express, 6 x SATA 6Gbps 1 x M.2, 8 x USB 3, 2 x USB 3.1 Type-A, 1 x USB 3.1 Type C, 1 x Gigabit LAN, 8-channel surround audio out, line in, mic, optical S/PDIF out

IGP display outputs 1 x DVI, 1 x HDMI, 1 x DisplayPort

Dimensions (mm) 305 x 244

ELITE
NEW ENTRY
P62

Asus Maximus VIII Gene / £142 inc VAT

CUSTOM PC PREMIUM GRADE

SUPPLIER www.scan.co.uk

The differences between micro-ATX and ATX boards have now shrunk to the point where you don't lose much by opting for a smaller board, especially if you buy the Asus Maximus VIII Gene. Aside from having fewer PCI-E slots, it offers all you get from an ATX board and, in some cases, more.

All the goodies of the Z170 chipset are here: an M.2 slot, on-board USB 3.1 ports (in addition to six USB 3 ports), four DDR4 DIMM slots, six SATA 6Gbps connectors, and the same EFI overclocking tools you would expect from ATX boards, with a similarly wide range of supported CPU multipliers, base clock frequencies and voltages. Notably, the rear panel is also completely free of USB 2 ports.

Similarly, there's been no skimping on the chunky chipset and VRM heatsinks, the latter of which are connected via a small heatpipe, and Asus has still managed to leave plenty of room around the power connectors. There should be few problems with longer video cards as well, as the SATA ports are all right-angled, and even the M.2 slot has space to spare – you'll even be able to squeeze a 22110 M.2 device in there, albeit obscured by the graphics card – a feature that not every ATX boards offers.

The board also happily accommodates dual-GPU setups, with space underneath both 16x PCI-E slots, although the limited room on micro-ATX boards means you sacrifice upgrade room elsewhere by doing so. There's a single 1x PCI-E slot underneath the second 16x slot, but it will be obscured if you install a second card. If you're using two dual-slot air-cooled cards then they will also be positioned right next to each other using this board, which isn't ideal.

Meanwhile, the I/O panel is quite crowded, with HDMI and DisplayPort outputs, BIOS-flashback and clear-CMOS buttons, and USB 3.1 type-A and type-C ports positioned at the top. Asus has even found room for seven fan headers on the board, along with power and reset buttons and a POST code display.

Then we have they comprehensive EFI system, which lacks none of the features of the larger Asus ATX motherboards. BIOS updates can be performed via USB or a direct Internet download, there's a separate Q-Fan control with customisable fan curves and the highly useful Asus SSD secure erase feature is present. It's full of features and it also has clear menus and a logical layout, making it a pleasure to use. We managed to squeeze 4.9GHz out of our Core i7-6700k Skylake processor with the other Asus ROG board on test, the Maximus VIII Ranger (see p44), and had similarly good results from the Gene. Again, it hit 4.9GHz, which is a faster frequency than we achieved from most other Z170 boards, and again this result was stable at a fairly low voltage of just 1.38V.

In fact, when overclocked, the Maximus VIII Gene was the overall fastest motherboard on test in RealBench 2015, showing you now lose nothing in terms of performance and overclocking by going for a micro-ATX board. The Gene was very quick at stock speed too, and its small size also helped with power efficiency, with our test system drawing just 128W at load at stock speed – the best result on test.

Conclusion

The Gene betters several ATX boards on test, with great performance, amazing overclocking abilities and a strong feature set.

PERFORMANCE 28/30

FEATURES 30/35

VALUE 29/35

OVERALL SCORE 87%

VERDICT

A feature set that belies its size, and its performance and overclocking abilities are superb too.

/SPECIFICATIONS

Chipset Intel Z170

CPU socket Intel LGA1151

Memory support 4 slots, max 64GB DDR4 (3800MHz - OC)

Expansion slots Two 16x PCI-E, one 1x PCI-E

Sound Realtek ALG1500

Networking Intel Gigabit LAN

Overclocking Base clock 40–650MHz, CPU multiplier 8–83x; max voltages, CPU 1.7V, RAM 2.0064V

Ports 1x PS/2, 2 x SATA Express, 6 x SATA 6Gbps, 1x M.2 , 6 x USB 3, 1 x USB 3.1 type-A, 1 x USB 3.1 type-C, 1 x LAN, 8-channel surround audio out, line in, mic, optical S/PDIF out

IGP display outputs 1 x HDMI, 1 x DisplayPort

Dimensions (mm) 244 x 244

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Asus Maximus VIII Ranger / £154 inc VAT

SUPPLIER www.ebuyer.com

Although the Maximus VIII Ranger is far from the cheapest board on test, it's still notably less expensive than other Asus Republic of Gamers boards, giving enthusiasts a chance to get their hands on Asus' ROG goodness without breaking the bank. It's good to see solid, large heatsinks on the VRMs and chipset, although there's no connecting heatpipe, as found on the other ROG boards. Free space around the power connectors isn't that generous either, but that's not a major problem. On the plus side, the main fan headers are positioned along the easily accessible top area of the board, including a connector for a pump, and the front and rear chassis fan headers are in the right places as well.

Meanwhile, there are six SATA ports and two SATA Express ports with right-angled connectors, and a single M.2 connector is located to the lower right of the motherboard, positioned below the middle 16x PCI-E slot. Placing the M.2 connector in this area of the board is better than placing it in a fiddly spot right under the top 16x slot, and there's also enough space for 22110 device compatibility. Of course, your M.2 device will be obscured if a graphics card is installed in that slot, but that's only likely to be an issue if you're building a dual-GPU setup.

There's also a single 1x PCI-E slot above the main 16x PCI-E slot, so it's always accessible even with two graphics cards installed. There's extra space between the top two 16x PCI-E slots too, giving room for plenty of airflow, and there's still a third slot you could use for a PCI-E SSD, rounding off a generally strong layout.

We were also pleased to see that the EFI is almost identical to the one included with the Maximus VIII Gene, with a great layout that's rich with tools for overclocking and system control. It carries over the same features too. Firmware updating via USB or over the Internet is possible, with a dedicated BIOS Flashback button at the rear. The useful SSD Secure Erase feature is there too, plus fan control software, profile saving to USB and a port renaming tool.

There are a few small differences between the Gene and Ranger though. You still get two USB 3.1 ports (type-A and type-C) but there are four USB 2 ports on the back, and only two USB 3 ports, which seems a bit mean – the Gene has no USB 2 ports on the back. As you would expect, the board also features on-board power and reset buttons, and a POST code display for easy testing.

As usual for a ROG board, though, the Ranger was great at overclocking. It managed to overclock our CPU to 4.9GHz while only needing a 1.36V vcore – well below the amount some boards needed to reach a lower 4.8GHz or 4.7GHz frequency. As with the Gene, the Ranger was also a fantastic performer in our tests, with both ROG boards occupying the top spots in our RealBench 2015 test, and in our Total War benchmarks.

Conclusion

Despite a couple of very minor niggles with the board layout, the Maximus VIII Ranger is otherwise very well designed and fast, and it offers a great EFI and some genuinely useful extra features. Throw its superb overclocking abilities into the mix, and the Ranger is the best-balanced enthusiast ATX motherboard on test, and it's priced reasonably too.

PERFORMANCE	FEATURES	VALUE	OVERALL SCORE
28/30	31/35	28/35	87%

VERDICT

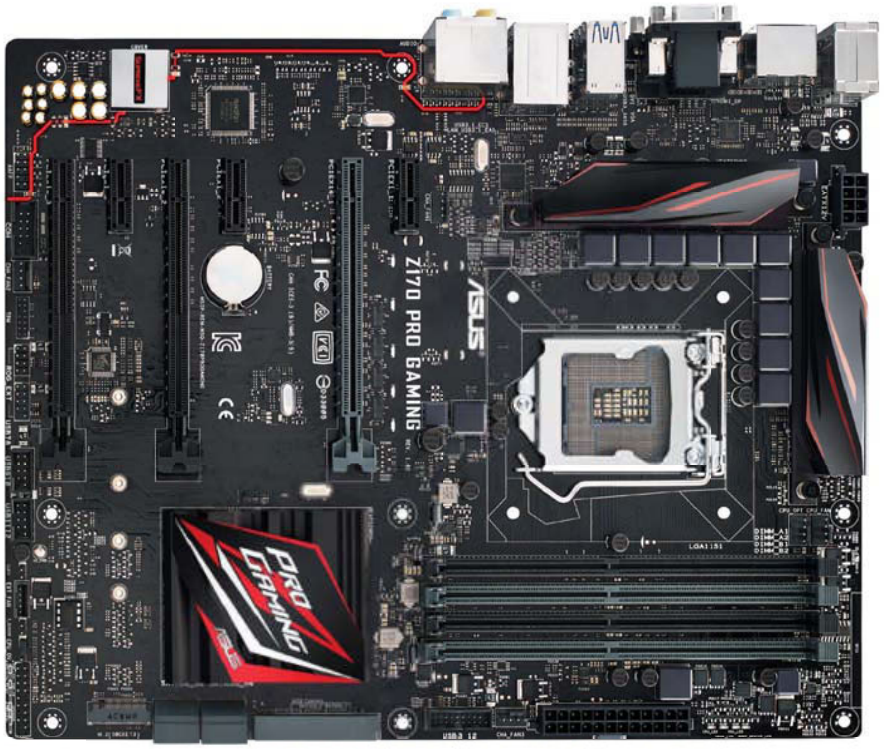
Well designed, fast, great at overclocking and rich with genuinely useful features. The Ranger is a great enthusiast motherboard for a surprisingly reasonable price.

/SPECIFICATIONS

Chipset Intel Z170
CPU socket Intel LGA1151
Memory **support** 4 slots, max 64GB DDR4 (3400MHz - OC)
Expansion slots Three 16x PCI-E, three 1x PCI-E
Sound Realtek ALC1500
Networking Intel i219v Gigabit Ethernet
Overclocking Base clock 40–650MHz, CPU multiplier 8–83x; max voltages, CPU 1.7V, RAM 2V
Ports 1 x PS/2, 2 x SATA Express, 6 x SATA 6Gbps 1 x M.2, 4 x USB 2, 2 x USB 3, 1 x USB 3.1 (type-A), 1 x USB 3.1 (type-C), 1 x Gigabit LAN, 8-channel surround audio out, line in, mic, optical S/PDIF out
IGP display outputs 1 x HDMI, 1 x DisplayPort
Dimensions 305 x 244

Asus Z170 Pro Gaming / £119 inc VAT

SUPPLIER www.scan.co.uk



Amusingly, the competition between Asus and Gigabyte seems to now extend to brand tie-ins with Wargaming.net. Gigabyte's Z170X-Gaming 3 has a World of Tanks logo, while Asus' Z170 Pro Gaming goes for World of Warships. You don't get much – it's just a code for a new cruiser and 15 days of premium access, but the close rivalry between motherboard firms now extends to the virtual battlefield as well as the marketplace.

The Z170 Pro Gaming has three 16x PCI-E slots, three PCI-E slots and a single M.2 slot. The positioning of these components is very good – the main graphics card won't block anything, there's a single unobscured 1x PCI-E slot above it and a free slot for airflow underneath, with another unobstructed 1x PCI-E slot below that. The M.2 slot also supports 22110 devices. The rest of the layout is great too – there's room around the power connectors, and the fan headers are well placed to the right of the VRM heatsinks. Six right-angled SATA 6Gpbs ports are also sensibly placed in the lower right of the board, joined by a single SATA Express port

The aforementioned heatsinks are a bit small, though, and there's no heatpipe to connect them. You do get an aesthetic lighting kit, however, with red LEDs below the model name and a strip by the SupremeFX sound system. You can toggle these lights on or off in the EFI, or set them to a 'breathing' mode. Unlike ASRock's cheaper Extreme4, though, there are no on-board power and reset buttons, or a clear-CMOS switch.

At the back, there's a stack of four USB 3 ports, with USB 3.1 type-A and type-C connectors, and another pair of USB 2 ports at the top. Interestingly, the IGP has four display outputs too – VGA, DVI, HDMI and DisplayPort – providing plenty of options.

Meanwhile, the EFI is up to the same high standard as the other Asus motherboards, and is an aspect of Asus products that stands out. Arguably, all manufacturers now offer an EFI that's good enough, but Asus goes further, with a great main screen, favourite settings, Q-Fan control with custom fan curves and OC profiles. Useful features such as USB BIOS Flashback and SSD Secure Erase are included too – the latter used to only be found on Asus' ROG boards.

The two Asus ROG boards on test and EVGA's Classified enabled us to overclock our Core i7-6700k processor to 4.9GHz, and unfortunately, the Z170 Pro Gaming couldn't quite hit this same level, topping out at 4.8GHz, but with a relatively comfortable voltage of 1.34V. That's still a good result, though, particularly from a £119 board. However, while the Z170 Pro Gaming was fast enough, it was noticeably behind most of the other boards on test in our performance benchmarks, but only by a small margin.

Conclusion

The Asus Z170 Pro Gaming can't quite compete with the ASRock Extreme4 in terms of value, and it isn't quite as quick as much of the competition, although the margin is small. However, it does offer a great EFI and a decent layout and, while it misses a few feature marks, it's great to see features such as SSD Secure Erase making it to a sub-£120 board. The Extreme4 might offer better value for money, but if the Z170 Pro Gaming's feature set is more appropriate for your needs, it's still a decent board for a reasonable price.

PERFORMANCE 26/30

FEATURES 27/35

VALUE 31/35

OVERALL SCORE 84%

VERDICT

A decent layout, EFI and a feature set for the money, although other boards are a little quicker and offer slightly better value.

/SPECIFICATIONS

Chipset Intel Z170

CPU socket Intel LGA1151

Memory support 4 slots, max 64GB DDR4 (3400MHz - OC)

Expansion slots Three 16x PCI-E, three 1x PCI-E

Sound Realtek ALC1150

Networking Intel Gigabit Ethernet

Overclocking Base clock 40–650MHz, CPU multiplier 8–83x; max voltages, CPU 1.7V, RAM 1.8V

Ports 1 x PS/2, 1 x SATA Express, 6 x SATA 6Gbps 1 x M.2, 2 x USB 2, 4 x USB 3, 1 x USB 3.1 type-A, 1x USB 3.1 type-C, 1 x Gigabit LAN, surround audio out, line in, mic, optical S/PDIF out

IGP display outputs 1 x VGA, 1 x DVI, 1 x HDMI, 1 x DisplayPort

Dimensions (mm) 305 x 244

EVGA Z170 Classified 4-Way / £345 inc VAT

SUPPLIER www.scan.co.uk

EVGA's Z170 Classified 4-Way is the only motherboard on test with 4-way SLI support. Normally, there aren't enough PCI-E lanes on a Z170 system for four graphics cards, but with the addition of a PLX chip, which artificially increases the number of lanes via multiplexing, it's possible to effectively squeeze more lanes from the Z170 chipset and run four Nvidia cards together. The Z170 Classified is also notable for its price. At £345, it's significantly more expensive than any other board on test.

On the plus side, it's great to see the use of particularly massive heatsinks that cover the VRMs and chipset, with large heatpipes running along the board. However, otherwise this board struggles to justify its price tag. It has a fairly standard array of ports. USB 3.1 is included, but only via a header on the board, while there are six standard USB 3 ports and two USB 2 ports at the back. There are eight SATA 6Gbps ports, though, which is fairly generous, with two SATA Express ports next to them. You also get two Intel Gigabit LAN ports, which could have some benefits in certain networked environments, or with NAS boxes that have dual NICs.

The Classified is also an E-ATX board, so it has extra space for a comfortable component layout. The top 16x PCI-E slot has plenty of space around it, but the single 4x PCI-E slot is guaranteed to be obscured by a card in the fourth 16x PCI-E slot. The M.2 slot sits right next to it too, meaning M.2 access will be tricky. What's more, EVGA recommends using the top and fourth slots for 2-way SLI, which will obscure these parts. Also, the twin 8-pin CPU power connectors are really close to the VRM heatsink, so fitting them will be a tight squeeze.

However, a major plus point is the universal use of right-angled connectors, including the ATX connector. Likewise, the audio and USB headers, as well as the SATA ports, are all angled, which will improve cable management and result in a tidier PC.

EVGA's EFI isn't bad either, with sensible decisions made for the layout of the splash screen. It shows the overclock settings on the front page with memory settings in a separate tab, which is chock full of timing controls. USB firmware updating is standard and the menu design is fairly simple, so you shouldn't get lost easily. However, there are none of the fancy features such as fan curve profiles or favourites sections you get with Asus' EFI, and there's no list of changes made as you exit either.

However, one area where the Classified excelled was in overclocking, being the only non-ROG board on test to get our CPU to 4.9GHz, although it required 1.4V to make it stable, which is more than the ROG boards and accounts for the highest overclocked power consumption on test. In terms of performance, the Classified was generally competitive in our benchmarks, but it faltered in our audio tests, where the on-board Creative Core 3D Audio system recorded a signal to noise ratio of -98.5dB(A) and dynamic range of 98.4dB(A), when every other board on test achieved results below -100dB(A) or above 100dB(A) respectively. The sound quality is respectable, but it's disappointing that it lacks the fidelity of much cheaper boards.

Conclusion

The EVGA Z170 Classified 4-Way's extensive SLI support, use of right-angled connectors and build quality all help it to stand out. However, a couple of shortcomings and some questionable layout choices make it hard to justify the price, making this board only worth considering for 4-way SLI Skylake builds. For everyone else, you can get much better value for money elsewhere.

PERFORMANCE 27/30

FEATURES 33/35

VALUE 16/35

OVERALL SCORE 76%

VERDICT

The only board on test with 4-way SLI support, and it's great to see so many angled connectors, but otherwise it struggles to justify its very high price.

/SPECIFICATIONS

Chipset Intel Z170

CPU socket Intel LGA1151

Memory support 4 slots, max 64GB DDR4 (3200MHz)

Expansion slots Five 16x PCI-E, one 4x PCI-E

Sound Creative Core 3D Audio

Networking Intel i219 Gigabit Ethernet, Intel i210 Gigabit Ethernet

Overclocking Base clock 100–340MHz, CPU multiplier 8–83x; max voltages, CPU 2V, RAM 2V

Ports 2 x SATA Express, 8 x SATA 6Gbps 1 x M.2, 2 x USB 2, 6 x USB 3, 2 x Gigabit LAN, 6-channel surround audio out, line in, mic, optical S/PDIF out

IGP display outputs 1 x HDMI, 1 x DisplayPort

Dimensions (mm) 304.8 x 263.5

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Gigabyte Z170X-Gaming 3 / £120 inc VAT

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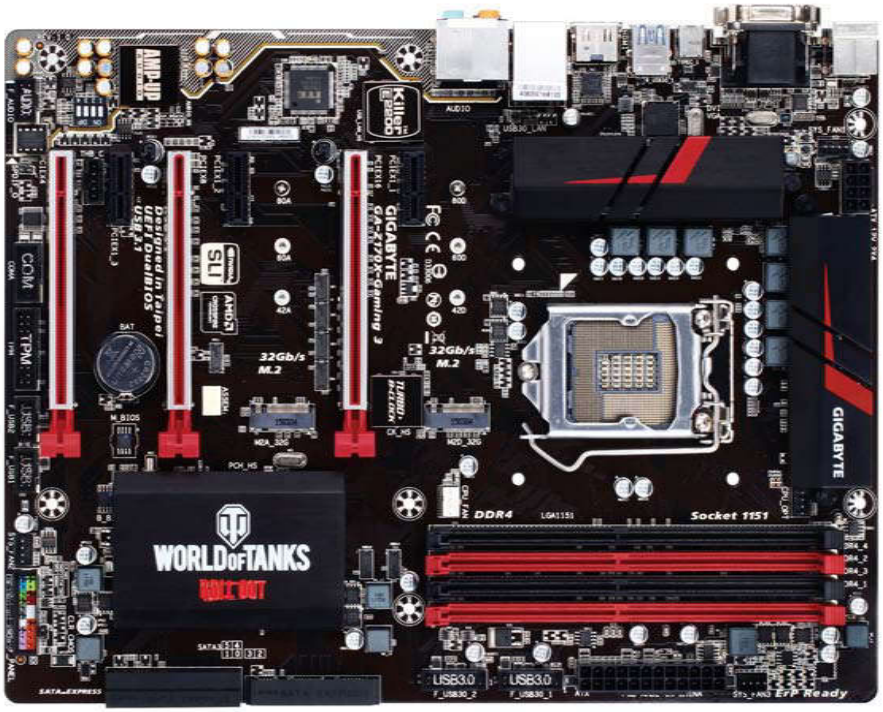

As with the Z170X-Gaming 5 (see p48), the Gaming 3 doesn't sacrifice many features compared with its pricier brethren. It looks almost identical to the Gaming 5, with three steel-reinforced red and white 16x PCI-E slots complementing the red and black colour scheme.

There are three 1x PCI-E slots, one of which sits above the top 16x slot for unobscured access, and there's a sizeable gap under the top 16x slot for graphics card airflow too.

As with the Gaming 5, the top M.2 slot is also well positioned, sitting above the top 1x slot, so nothing can obscure it, except maybe a chunky CPU cooler. There's another M.2 slot further down too, and it's great to see support for two M.2 cards on a £120 product, although they're limited to holding 2280 cards.

The layout is good in most other areas. There's no heatpipe connecting the VRM heatsinks, although the heatsinks themselves are still pretty chunky. As with the Gaming 5, though, the top heatsink might get in the way of the 8-pin CPU power connector, and the fan headers are all over the place.

There are also six right-angled SATA 6Gbps and three SATA Express ports in the lower section of the board, which is good to see. However, the status LED and buttons in the top right of the Gaming 5 are no longer found on the Gaming 3 and, unlike ASRock's Extreme4, there are no on-board power and reset buttons either. Meanwhile, the only lighting on the board is found around the audio circuits, although lighting is hardly an essential motherboard feature.

Meanwhile, at the rear is the standard USB port array – two USB 2 ports at the top, three USB 3 ports and both USB 3.1 type-A and type-C sockets. You also get VGA, DVI and HDMI connectors, but lose the DisplayPort output found on Gigabyte's pricier boards.

As with the other Gigabyte motherboards on test, the EFI system is generally fine, but lacking in a few notable areas. It looks just like the system on the Gaming 5, with the same strange layout in some places, such as menus containing only two items, and there are no options for fan curves. Of course, the layout of an EFI system isn't a major reason to avoid any motherboard, but it's an area where the competition has an upper hand.

The Gaming 3 is also let down ever so slightly by thermal throttling when overclocking our CPU to 4.8GHz, so we had to clock it down to 4.7GHz, which was perfectly stable at 1.28V. That's still a good result, and it's not as if most people are going to run their CPU at 4.8GHz 24/7 anyway, but again the competition can do better. Like the Gaming 5, the Gaming 3 also lacked in the performance stakes at stock speed – it isn't slow, but it's definitely behind the other boards on test. However, its audio performance was superb, achieving the best audio fidelity results on test – a great result for a £120 board.

Conclusion

The Z170X-Gaming 3 has plenty going for it, including dual M.2 ports, an attractive price and superb audio quality. However, the cheaper ASRock Z170 Extreme4 offers more enthusiast features and overclocking headroom, and Gigabyte's EFI needs some work too. If your top priority is audio performance, though, and you're on a tight budget, the Z170X-Gaming 3 is still a decent board for a good price.

PERFORMANCE	FEATURES	VALUE	OVERALL SCORE
26/30	25/35	29/35	80%

VERDICT

Great audio quality and dual M.2 ports for a tempting price, but it falls behind the competition in terms of enthusiast features and overclocking headroom.

/SPECIFICATIONS

Chipset Intel Z170
CPU socket Intel LGA1151
Memory support 4 slots, max 64GB DDR4 (3466 MHz - OC)
Expansion slots Three 16x PCI-E, three 1x PCI-E
Sound Realtek ALC1150
Networking Killer Gigabit Ethernet
Overclocking Base clock 80–500MHz, CPU multiplier 8–27x; max voltages, CPU 1.8V, RAM 2V
Ports 1 x PS/2, 3 x SATA Express, 6 x SATA 6Gbps, 2 x M.2, 2 x USB 2, 3 x USB 3, 1 x USB 3.1 (type-A), 1 x USB 3.1 (type-C), 1 x Gigabit LAN, 8 channel surround audio out, line in, mic, optical S/PDIF out
IGP display outputs 1 x VGA, 1 x DVI, 1 x HDMI
Dimensions (mm) 305 x 235

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Gigabyte Z170X-Gaming 5 / £142 inc VAT

SUPPLIER www.box.co.uk

Gigabyte's Z170X-Gaming 5 is a little cheaper than the Gaming 7 (see Issue 146, p21), but retains many of its features. It has a similar black, white and red colour scheme, with three steel-reinforced red and white 16x PCI-E slots complementing the racy visual design.

There are four 1x PCI-E slots, up from three on the Gaming 7, dual M.2 ports remain and there are still two Ethernet ports – one from Intel, the other from Killer. There are a few small differences between the two boards, though. The heatpipe connecting the VRM coolers has gone, and there are no covers on the I/O panel or audio circuitry either.

In terms of layout, the area around the 8-pin CPU power connector is fairly crowded, with a fan header and the edge of the VRM heatsink right next to it, but the rest of the connectors are easier to access, including the fan headers. The six SATA ports and three SATA Express ports are all right-angled too, and there are clear labels on the USB headers. Meanwhile, an error code display, and OC and Eco buttons sit at the top right of the board, with the OC button automatically loading a Gigabyte-optimised overclocking preset, and the ECO button enabling power-saving features. However, a simple set of power, reset and clear-CMOS buttons would arguably be more useful here.

On the rear I/O panel, you get four USB 2 ports, USB 3.1 in type-A and type-C forms, and three USB 3 ports. HDMI and DisplayPort video outputs are provided for the IGP as well.

As on a few other boards, the top M.2 slot is sensibly positioned so that it's unobstructed by any graphics card, but it's good to see the lower slot positioned away from the second PCI-E graphics slot – so you'll be able to access both M.2 ports, even with a dual-GPU setup – a smart move from Gigabyte that other firms should follow.

Meanwhile, Gigabyte's EFI is practically identical to the one on the Gaming 7. It's pretty solid, with a straightforward splash screen and extras such as USB updating. However, a few features are notably missing, such as a favourites system and fan control curves. The layout could do with an overhaul as well.

When overclocking our Core i7-6700K, the Gaming 5 hit the same 4.8GHz clock speed as the Gaming-7, with a vcore of 1.42V. That isn't a bad result, but Asus' Maximus VIII Ranger costs a little over a tenner more and managed to hit 4.9GHz with just a 1.36V vcore.

Interestingly, the Gaming 5 also scored the lowest system score in our RealBench 2015 suite. Likewise, all the Gigabyte boards on test could only manage a 56fps minimum in Total War: Attila at stock speed, while other boards hit 60fps.

The performance difference between all the boards on test isn't huge, but we expect a board costing £142 to perform better.

On the plus side, the on-board audio quality was superb, with both the Gaming 5 and Gaming 3 achieving the best signal-to-noise ratio and dynamic range results on test, and you can even upgrade the OP-AMP too.

Conclusion

The Gaming 5 offers great looks and fantastic audio quality, but it's slightly let down by its EFI system, and the similarly priced competition offers faster performance and superior overclocking.

PERFORMANCE 26/30

FEATURES 27/35

VALUE 27/35

OVERALL SCORE 80%

VERDICT

Great looks and superb audio quality, but the EFI needs work, while its performance and overclocking abilities are bettered by the competition.

/SPECIFICATIONS

Chipset Intel Z170

CPU socket Intel LGA1151

Memory support 4 slots, max 64GB DDR4 (3466MHz - OC)

Expansion slots Three 16x PCI-E, four 1x PCI-E

Sound Realtek ALC1150

Networking Killer E2201 Gigabit Ethernet, Intel Gigabit Ethernet

Overclocking Base clock 80–500MHz, CPU multiplier 8–127x; max voltages, CPU 1.8V, RAM 2V

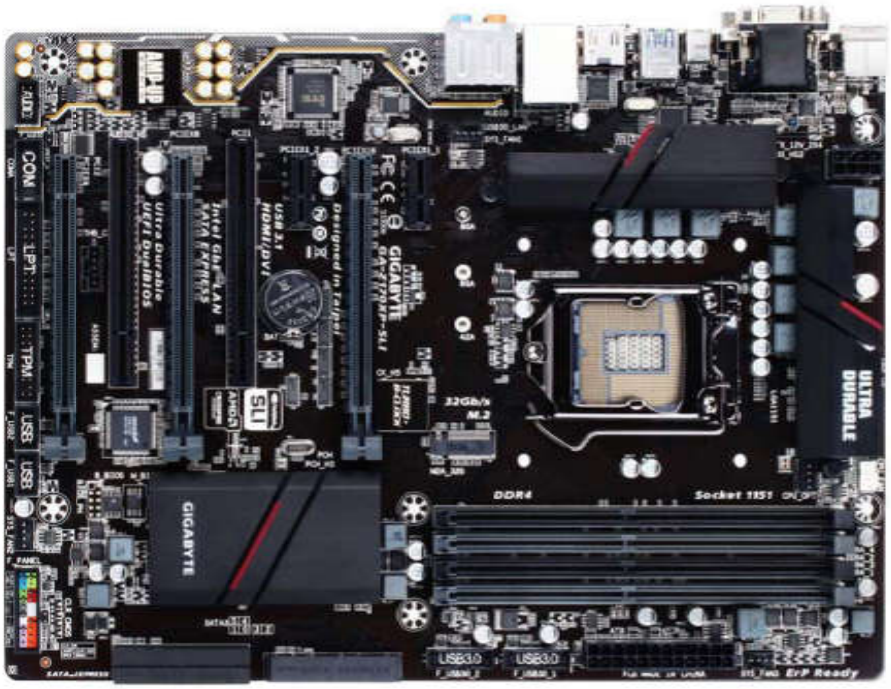
Ports 3 x SATA Express, 6 x SATA 6Gbps, 2 x M.2, 4 x USB 2, 3 x USB 3, 1 x USB 3.1 (type-A), 1 x USB 3.1 (type-C), 2 x Gigabit LAN, 8-channel surround audio out, line in, mic, optical, S/PDIF out

IGP display outputs 1 x HDMI, 1 x DisplayPort

Dimensions (mm) 305 x 244

Gigabyte Z170XP-SLI / £106 inc VAT

SUPPLIER www.box.co.uk



As the cheapest board on test this month, the Z170XP-SLI's feature list deserves particular scrutiny. Cheaper boards usually sell in greater volume than the deluxe offerings, but what do you lose by plumping for a £106 motherboard? In the case of the Gigabyte Z170XP-SLI, not an awful lot in terms of essentials. There's a single M.2 slot, three 16x PCI-E slots, which support 2-way SLI or 3-way CrossFire. It also supports up to 64GB of dual-channel DDR4 memory, with the same maximum overclocked frequency of 3466MHz as the Z170X-Gaming 3 and Z170X-Gaming 5.

There are two 1x PCI-E slots and, unusually, two PCI slots, which can be handy for moving older expansion cards over to a new PC, but they're obsolete in terms of new hardware now. There's no sign of austerity with storage either, with three SATA Express ports and six SATA 6Gbps connectors. Like most Z170 motherboards, there's only one M.2 slot, although the other two more expensive Gigabyte boards in this Labs notably offer two. The board is a little bare – it's just a simple black PCB with no on-board power and reset buttons, no POST error code readout and no easy-access clear-CMOS switch – features that are all found on the ASRock Extreme4, which costs just a few quid more.

It's good to see USB 3.1 is included on the rear I/O panel as well, with both type-A and type-C connectors, a feature that hasn't been cut from the specification to create an artificial difference between the Z170XP-SLI and pricier offerings. Also on the back you'll find a pair of USB 2 ports and three USB 3 ports. PS/2 and analogue VGA display outputs are included too, continuing the theme of support for legacy standards, although there are DVI and HDMI connectors too.

The board layout is generally okay, and includes right-angled SATA ports to help with neat cabling and to avoid interfering with graphics card placement. The area around the 8-pin CPU connector is a little crowded, though, and the connector has been rotated 90 degrees from its usual horizontal positioning. Also, with two graphics cards installed, the lower 1x PCI-E slot will be inaccessible, leaving just one at the top. Above this slot sits the M.2 port, which will only support up to 2280 devices, but is very sensibly positioned so that nothing can obscure access to it.

As with MSI and Asus, Gigabyte has chosen to include the same EFI system across its product range, which means it's well laid out, and supports firmware updating via USB, but it also carries the same problems as the other Gigabyte boards on test. The menus in this EFI system seem to defy convention, with frequency, memory and voltage settings all in separate menus. To overclock your chip, you'll need to go back and forth between them, which will get frustrating. Some of the menus have only two settings in them as well, and although you can save OC profiles, there's no favourites menu or a list of changes on exit.

After we worked around these problems, though, we overclocked our Core i7-6700K. Despite its low price, the Z170XP-SLI is still a decent overclocker, managing to get our chip to 4.8 GHz, with a relatively reasonable 1.38V vcore.

This result places it above some of the other Z170 boards on test, which only made it to 4.6GHz or 4.7GHz, including Gigabyte's own Z170X-Gaming 3.

Conclusion

The Gigabyte Z170XP-SLI may only cost £106, but it has some surprisingly powerful overclocking abilities, SLI support and a decent layout. However, it suffers from an unintuitive EFI layout, and its feature set is lacking compared with the similarly priced ASRock Extreme4.

PERFORMANCE 27/30

FEATURES 24/35

VALUE 30/35

OVERALL SCORE 81%

VERDICT

A well laid-out SLI board with decent overclocking abilities for a low price. However, the EFI needs work and ASRock's Extreme4 offers more features.

/SPECIFICATIONS

Chipset Intel Z170

CPU socket Intel LGA1151

Memory support 4 slots, max 64GB DDR4 (3466MHz - OC)

Expansion slots Three 16x PCI-E, two 1x PCI-E, two PCI

Sound Realtek ALC1150

Networking Intel Gigabit Ethernet

Overclocking Base clock 80–500MHz, CPU multiplier 8–127x; max voltages, CPU 1.8V, RAM 2V

Ports 3 x SATA Express, 6 x SATA 6Gbps, 1 x M.2, 2 x USB 2, 3 x USB 3, 1 x USB 3.1 (type-A), 1 x USB 3.1 (type-C), 1 x Gigabit LAN, 8-channel surround audio out, line in, mic

IGP display outputs 1 x VGA, 1 x DVI, 1 x DisplayPort

Dimensions (mm) 305 x 225

MSI Z170A Gaming M7 / £175 inc VAT

SUPPLIER www.ebuyer.com

There's a strange assumption amo motherboard makers that red and black is the colour scheme of choi for PC gamers. Not only is it used on the majority of Z170 motherboards, but it's also seen on many cases and even gaming-focused displays. Assuming you like this colour combo, of all the boards on test, MSI has made the best use of these two colours with the Gaming M7. The VRM and chipset heatsinks are decorated with deep red go-faster stripes, and the same even goes f some of the connections directly on the PCB. There are some LEDs on the board too – a red strip outlines the audio isolation circuit, whil bright red light enables you to diagnose any network problems with the LAN port.

In general, the build quality is excellent. A heatpipe connects the chunky VRM heatsin the GPU slots are reinforced, there's plenty of space around the power connectors, and the fan headers and on-board buttons are all easily accessible. Along with the usual power and reset buttons, there's also a Game Boost button, which provides a quick voltage and multiplier boost, and there's a POST code error readout too.

There are the usual three 16x PCI-E slots and four 1x PCI-E slots. The top 1x PCI-E slot is also sensibly positioned above the main graphics slot, parallel with one of the two M.2 ports. Although the second and third 1x PCI-E slots will be obscured by dual-slot graphics cards used in the nearby 16x slots, it's unlikely that any component will block the first and fourth 1x slots. The lower M.2 slot is directly beneath the second 16x graphics slot, so it's easily accessible in most cases, although it will be obstructed by a second graphics card.

Meanwhile, the rear I/O panel sports two USB 2 ports and two USB 3 ports at the rear, along with two USB 3.1 ports with type-A and type-C connectors. An additional USB 2 port is also provided for USB firmware updating, with a button placed next to it. The SATA ports are a similarly standard offering, with six SATA 6Gbps ports and two SATA Express ports, all of which are right angled.

The Click Bios 5 EFI is pretty much identical to the one used on the MSI Z170 Titanium Edition, with a splash screen that allows easy access to the main system functions and settings, as well as the boot order. The Advanced menu is easy to navigate, with a neat layout that has six main icons to guide you around. The overclocking settings are also thorough and kept in one place, including voltage and DRAM frequency controls. A favourites system is included too, which is very simple to use. Overall MSI's interface design is hard to fault, and certainly deserves the 'EZ' name for its ease of use.

Like most of the boards on test, the Z170 Gaming M7 overclocked our Core i7-6700K to 4.8GHz. However, it required a 1.44V vcore, resulting in the second highest overclocked power consumption on test at load. The Z170A Gaming M7 is a solid performer, though, pushing out decent benchmark results in all our tests.

Conclusion

The Z170A Gaming M7 has a solid EFI, strong performance, plenty of features, easy overclocking and a good layout. It isn't cheap, though, and at this price, it's up against some serious competition from Asus' cheaper Maximus VIII Ranger, which is similarly rich in features and also a better overclocker.

PERFORMANCE 27/30

FEATURES 31/35

VALUE 26/35

OVERALL SCORE 84%

VERDICT

A solid board with a decent EFI, strong performance and a good layout, but it's up against serious competition from Asus' ROG boards.

/SPECIFICATIONS

Chipset Intel Z170

CPU socket Intel LGA1151

Memory support 4 slots, max 64GB DDR4 (3600MHz - OC)

Expansion slots Three 16x PCI-E, four 1x PCI-E

Sound Realtek ALC1150

Networking Killer E2400 Ethernet

Overclocking Base clock 70 – 655.25MHz, CPU multiplier 8–83x; max voltages, CPU 2.155V, RAM 2.2V

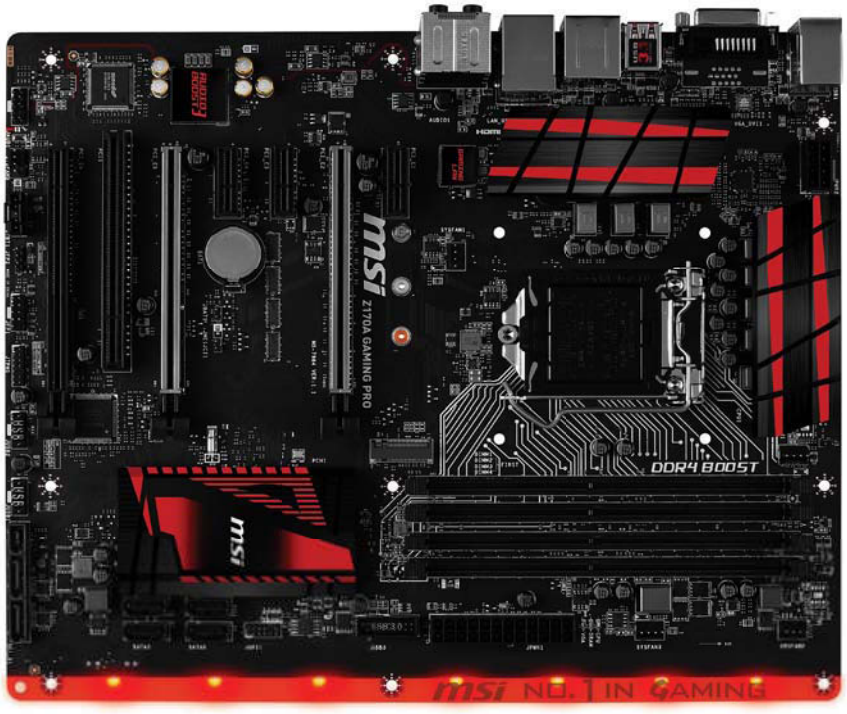
Ports 2 x SATA Express, 6 x SATA 6Gbps, 2 x M.2, 3 x USB 2, 2 x USB 3, 2 x USB 3.1, 1 x Gigabit LAN, 8-channel surround audio out, line-in, mic, optical S/PDIF out

IGP display outputs 2 x HDMI, 1 x DisplayPort

Dimensions (mm) 305 x 244

MSI Z170A Gaming Pro / £120 inc VAT

SUPPLIER www.scan.co.uk



Much like the other less expensive Z170 motherboards on test, the MSI Z170A Gaming Pro only omits a few of the main features found on its bigger siblings. What's more, the Z170A Gaming Pro looks better than your average budget board. The black and red theme so loved by many PC component manufacturers is used to full effect here. The chunky VRM and chipset heatsinks are red on the top, while the rest of the board is a mix of black and grey.

There's a red lighting kit too, with a section at the side lighting up to show the MSI logo and a few more LEDs dotted around the board. When powered down, this side section doesn't look half as good though – it's basically a yellow strip along the side of the board.

Meanwhile, three 16x PCI-E slots and three 1x PCI-E slots provide a good set of expansion options, with the two main 16x slots reinforced with steel. One of the 1x PCI-E slots is sensibly placed right at the top to ensure it won't be obstructed by other components, while there's an extra slot's worth of space for extra airflow between the two main graphics slots. It looks fine, and there's even a PCI slot, which could be handy if you have any aging PCI gear you still want to use.

The SATA Express ports are cut down to just one for this board, although that isn't a big deal considering the lack of SATA Express devices. There are also six standard SATA 6Gbps ports to the right and bottom of the board. Unfortunately, they aren't right-angled, making for messier cabling and the potential for SATA cables to obstruct a second graphics card. The M.2 slot is sensibly placed above the top 16x PCI-E slot though. At the back, you get the standard pair of USB 2 ports at the top, next to a PS/2 port and two USB 3.1 type-A ports and four more USB 3 ports.

Aside from the lack of right-angled SATA ports, the layout is pretty good – ample space is provided around the fan headers and power connectors. Nothing is missing in the EFI either. In fact, the EFI looks almost identical to the system on the pricier MSI motherboards.

That's good, since the excellent MSI Click BIOS 5 system is easy to navigate and has all the extras too, with the ever-useful Board Explorer (which highlights each part on a photo of the board), fan monitor and USB BIOS update features included, and it lists any changes on exit.

Unfortunately we didn't get too far when we tried overclocking our Skylake CPU. With the load line calibration set as high as it could go (level 4), we only managed to squeeze 4.6GHz from the Z170A Gaming Pro, with a 1.32V vcore. Higher speeds and voltages either failed or resulted in thermal throttling, putting the Z170A Gaming Pro at the bottom of the pack for overclocking, although its overall stock performance is still generally very good. One exception, though, is M.2 read performance, which was still fast, but significantly slower than every other board on test. The audio quality, while still reasonable, was also beaten by most of the competition.

Conclusion

The MSI Z170A Gaming Pro has a lot to offer, with plenty of expansion options and a great EFI at a decent price. However, it's up against stiff competition in this price bracket, and both the ASRock Extreme4 and Asus Z170 Pro Gaming offer superior overclocking abilities and better value for similar money.

PERFORMANCE 27/30

FEATURES 25/35

VALUE 28/35

OVERALL SCORE 80%

VERDICT

A good EFI and decent expansion options, but there's serious competition at this price, and the Z170A Gaming Pro falls short on overclocking abilities.

/SPECIFICATIONS

Chipset Intel Z170

CPU socket Intel LGA1151

Memory support 4 slots, max 64GB DDR4 (3600MHz - OC)

Expansion slots Three 16x PCI-E, three 1x PCI-E, one PCI

Sound Realtek ALC1150

Networking Intel Gigabit Ethernet

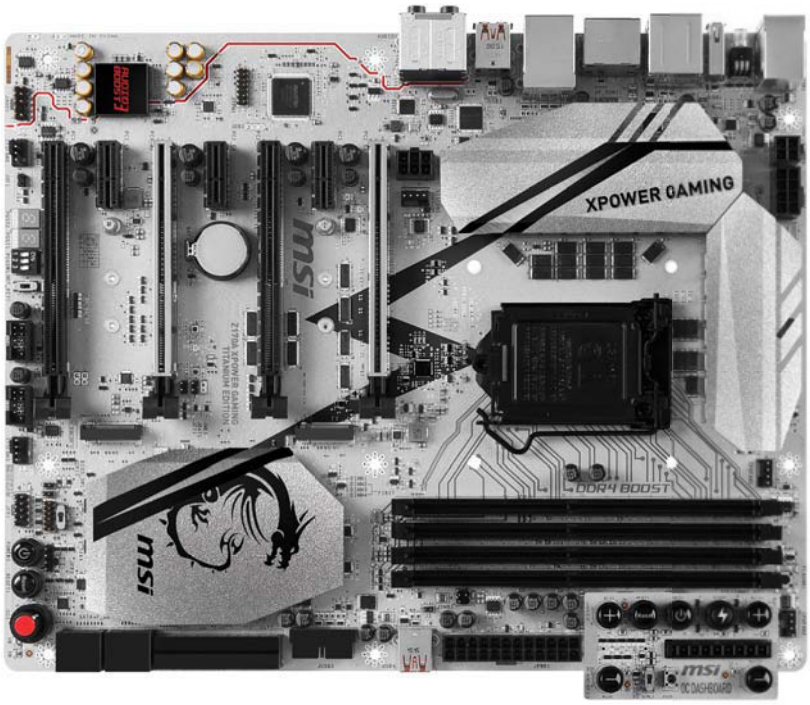
Overclocking Base clock 98–341MHz, CPU multiplier 8–83x; Max voltages, CPU 2.155V, RAM 2.2V

Ports 1 x PS/2, 1 x SATA Express, 6 x SATA 6Gbps, 1 x M.2, 2 x USB 2, 4 x USB 3, 2 x USB 3.1 (type-A), 1 x LAN, 8-channel surround audio out, line in, mic, optical S/PDIF out

IGP display outputs 1 x DVI, 1 x DisplayPort

MSI Z170A Xpower Gaming Titanium Edition / £227 inc VAT

SUPPLIER www.scan.co.uk



MSI's Xpower Gaming Titanium Edition is possibly the best-looking motherboard we've ever seen, sporting a striking light grey colour scheme across the PCB.

The layout is superb too. There are four 16x PCI-E slots and three 1x PCI-E slots, with ample space underneath slots 1-3 for a 3-way graphics setup using decent-sized coolers, and slots 1 and 3 are reinforced with steel. Meanwhile, the use of right-angled SATA connectors means your SATA cables won't get in the way of longer graphics cards.

There are also two M.2 slots, although they're positioned between the 16x PCI-E slots, so access will be blocked when cards are installed. You're restricted to 2280 cards too, but the good news is that you can create an M.2 RAID array for super-fast storage transfer rates. There's plenty of space around the 24-pin and 8+4 pin power connectors too. The on-board 6-pin PCI-E power connector for the top graphics card slot won't be obscured by a card either, although there's a fan header next to it which might get in the way.

Then there's the OC dashboard, which uses a special header to give you on-board overclocking tools, enabling you to take the base clock and multiplier up and down. It may not be used by everyone, but it's a handy extra if you want to overclock your board and don't want to faff around in the EFI. However, the voltage readouts aren't essential unless you're really into competitive overclocking.

You also get a generous count of eight SATA 6Gbps ports, with two SATA Express ports next to them.

Meanwhile, power and reset buttons sit in the lower right, along with a clear-CMOS button, and there's a multi-BIOS switch and POST readout towards the lower left. Also of interest is the complete discharge button, which erases every single setting, including ones left intact by a clear-CMOS operation.

MSI also has its own system for easy BIOS updating without needing a CPU installed. It's called FlashB1, and it works using a dedicated USB port on the I/O panel and a button at the top.

The EFI follows most usual conventions, with a splash screen clearly displaying the main system information and quick access to the most useful functions such as the boot order. The hardware monitor tab gives you custom curves to control the speed of each fan, and it has a physical board diagram too, displaying the components connected at any time. Rounding it off is a set of five favourites menus, used for frequently accessed settings, and the overclocking features are held together in one menu.

As one of the pricier boards on test, we were hoping for great overclocking performance, and the MSI managed to overclock our CPU to 4.8GHz at 1.32V. That's a good result in terms of voltage, but we couldn't get a stable 4.9GHz frequency, with the board failing even when using vcores well above 1.4V. All of this places it just below the Asus ROG boards in terms of overclocking performance. The Xpower Gaming TE also performed solidly, sitting only just below the two ROG boards in lots of our tests.

Conclusion

The Z170A Xpower Gaming Titanium Edition might be comparatively expensive, but it offers a fantastic layout, loads of enthusiast features, solid performance and great looks.

PERFORMANCE 27/30

FEATURES 33/35

VALUE 22/35

OVERALL SCORE 82%

VERDICT

Dashing good looks, a great layout and loads of features make the Xpower Gaming TE a cracking premium motherboard.

/SPECIFICATIONS

Chipset Intel Z170

CPU socket Intel LGA1151

Memory support 4 slots, max 64GB DDR4 (3600 MHz - OC)

Expansion slots Four 16x PCI-E 3, three 1x PCI-E

Sound Realtek ALC1500

Networking Intel Gigabit LAN

Overclocking Base clock 75–655.25MHz, CPU multiplier 8–83x; max voltages: CPU 2.155V, RAM 2.2V

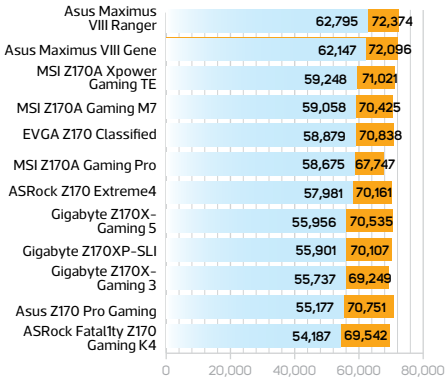
Ports 6 x SATA 6Gbps, 2 x SATA Express, 2 x M.2, 3 x USB 2, 4 x USB 3, 2 x USB 3.1, 1 x Gigabit LAN, 8-channel 'Nahimic' surround audio out, line in, mic, optical, S/PDIF out

IGP display outputs 2 x HDMI, 1 x DisplayPort

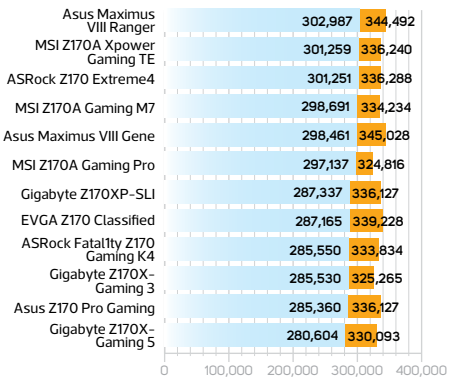
Dimensions (mm) 305 x 244

CPC REALBENCH 2015

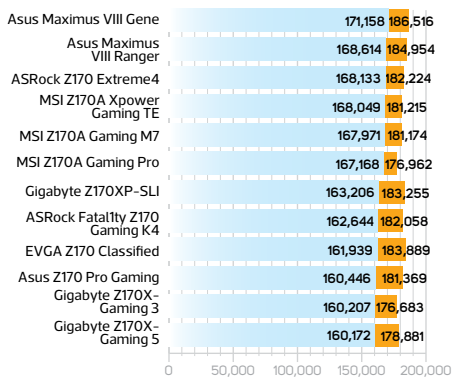
GIMP IMAGE EDITING



HANDBRAKE H.264 VIDEO ENCODING

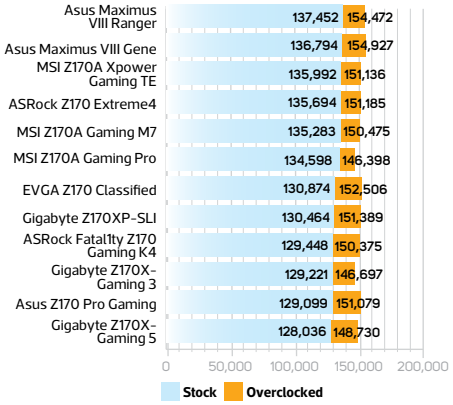


HEAVY MULTI-TASKING



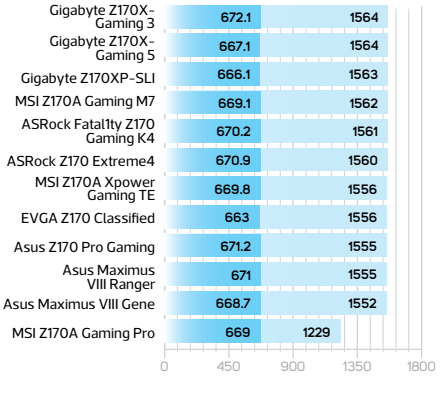
STORAGE

SYSTEM SCORE



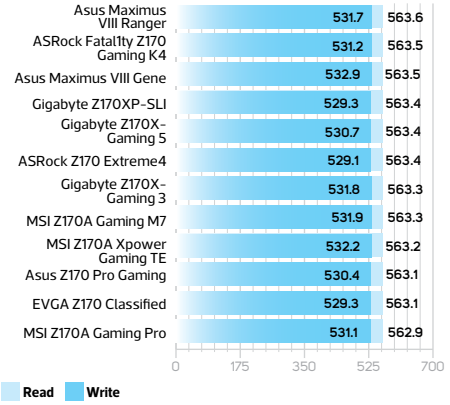
M.2 SPEED (MB/SEC)

CrystalDiskMark 32-queue-depth sequential



Z170 SATA 6GBPS SPEED (MB/SEC)

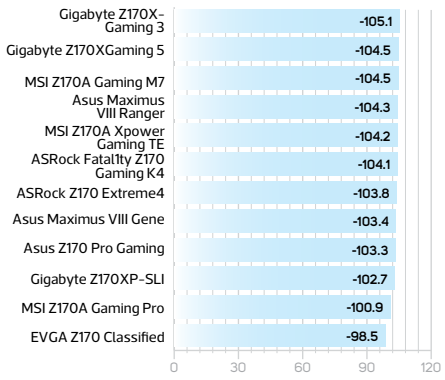
CrystalDiskMark 32-queue-depth sequential



AUDIO PERFORMANCE

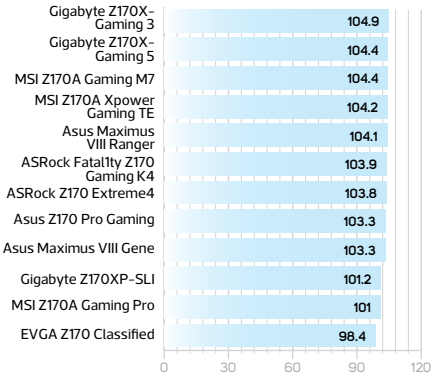
NOISE LEVEL (DBA)

Rightmark Audio Analyzer 96kHz



DYNAMIC RANGE (DBA)

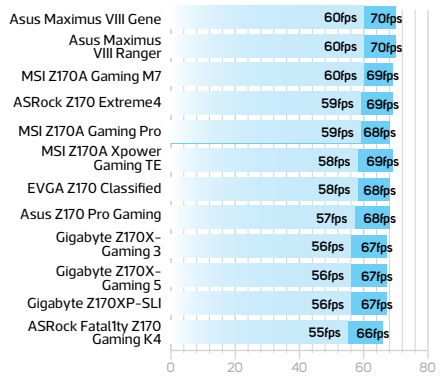
Rightmark Audio Analyzer 96kHz



GAMING

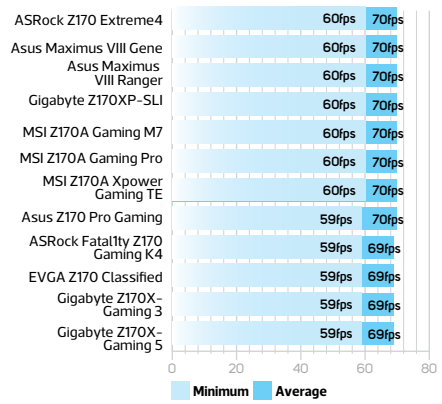
STOCK SPEED TOTAL WAR: ATTILA

1,920 x 1,080, Quality, 0x AA



OVERCLOCKED TOTAL WAR: ATTILA

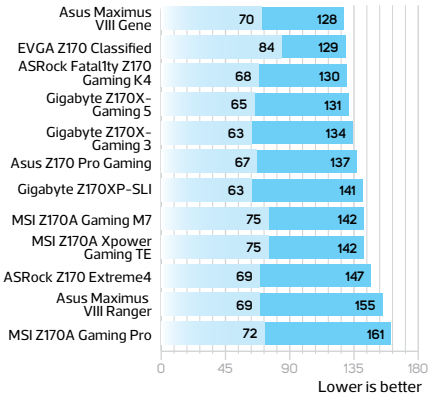
1,920 x 1,080, Quality, 0x AA



TOTAL SYSTEM POWER CONSUMPTION

STOCK POWER CONSUMPTION (WATTS)

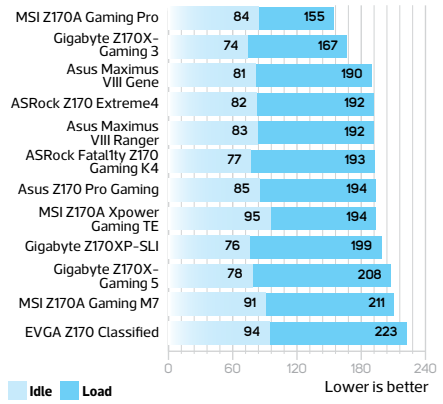
Windows desktop / Prime95 smallfft



Lower is better

OVERCLOCKED POWER CONSUMPTION (WATTS)

Windows desktop / Prime95 smallfft



Lower is better

PC system reviews

GAMING PC

Chillblast Fusion Fury Nano / £1,619 inc VAT

SUPPLIER www.chillblast.com

Chillblast's Fusion Nano might be small, but it uses the stupendous AMD Radeon R9 Nano (see p18) to cram an unprecedented amount of power inside its tiny case. The R9 Nano uses the Fiji GPU core that underpins its Fury X cards, and the use of 4GB of high-bandwidth memory on the GPU package, rather than big GDDR5 chips, has enabled AMD to use a pint-sized PCB too.

However, the Fury X requires liquid cooling, so AMD has turned down the Nano's GPU clock, so it can be chilled with a hybrid air and vapour-chamber cooler.

The new GPU is backed up by a Core i7-6700K Skylake CPU, which features Hyper-Threading support to boost multi-threading performance, and Chillblast has overclocked it to 4.4GHz – a comparatively modest overclock, but one that makes sense in a small chassis where airflow is limited.

Of course, the tiny size of this PC limits what Chillblast can do in terms of storage, but the Fusion still includes an SSD and hard disk. The boot drive is a Samsung SM951 M.2 SSD that uses four PCI-E 3 lanes and is attached to the rear of the motherboard, while the hard disk is a 2.5in 1TB hybrid drive.

The Asus Z170I Pro Gaming motherboard (see p26) also sports some decent features, such as Asus' SupremeFX audio circuitry and dual-band 802.11ac Wi-Fi. The rear panel is good too – four USB 3 ports, two USB 3.1 (type-A) ports, an optical S/PDIF and five audio jacks are included, plus HDMI and DisplayPort outputs.

It even has some LEDs and spare SATA ports, but neither are really practical in this machine – the lights are hidden, and the single spare 2.5in bay is blocked by cables. Of course, the form factor naturally restricts it to a single 16x PCI-E slot and two memory slots. The latter can handle 32GB of DDR4 memory, with Chillblast installing 16GB of modest 2133MHz DDR4 RAM.

The high-end silicon is packed inside a red Raijintek's Metis chassis, which looks great; the brushed metal is immaculate and the edges are bevelled to a shine. The panels aren't too thick, as it's still a budget case, but build quality is good, and the Raijintek is both sturdy and light enough to lug to LAN events.

The two side panels are held on by small screws and lift away easily. The interior is cramped, but the layout has been sensibly arranged to eke the most from a small space.

Meanwhile, the PSU is installed vertically at the front of the case with a cable that runs to the rear of the chassis, and the motherboard is installed upside down.

There's no room to hide cables, but Chillblast has kept the interior as neat as possible. PSU cables run around the unit, bundled above it, which leaves the central area of the case free for the Corsair Hydro H75. The Corsair liquid-cooling unit has two 120mm fans, and Chillblast has sensibly cut a hole directly above the Nano's 90mm fan to aid air intake.

The Fusion sports Chillblast's standard five-year warranty, which has two years of collect and return parts and labour cover, plus a further three years return to base, labour only.

/SPECIFICATIONS

CPU 4GHz Intel Core i7-6700K overclocked to 4.4GHz

Motherboard Asus Z170I Pro Gaming

Memory 16GB Crucial 2133MHz DDR4

Graphics Asus Radeon R9 Fury Nano 4GB

Storage 250GB Samsung SM951 M.2 SSD, 1TB Seagate hybrid hard disk

Case Raijintek Metis

Cooling CPU: Corsair Hydro H75 with 2 x 120mm fans; GPU: 1 x 90mm fan

PSU Corsair CS650M 650W

Ports Front: 2 x USB 3, 2 x audio; rear: 4 x USB 3, 2 x USB 3.1 Type-A , 2 x USB 2, 1 x PS/2, 1 x Gigabit Ethernet, 1 x optical S/PDIF, 5 x audio

Operating system Windows 10 Home 64-bit

Warranty Two years collect and return parts and labour, followed by three years return to base labour only

Performance

The Chillblast had no problem playing games at 2,560 x 1,440. Even Crysis 3 proved no problem, with the Chillblast never dropping below 38fps. AMD says the Nano can manage 4K gaming, but its performance at this extreme resolution isn't as clear-cut in this machine. Its Shadow of Mordor minimum of 37fps is fine but its Battlefield 4 minimum of 25fps is only borderline playable, and in Crysis 3, the minimum slipped to an unplayable 20fps. The Battlefield 4 result is possibly a result of the card throttling inside the small chassis, as the card did much better in this test in our review using our standard graphics test rig. Nevertheless, a playable frame rate at 4K is still a good result.

The overclocked Core i7 processor puts up a good fight too, achieving great results in our benchmarks, with an overall system score of 144,701. The Samsung SM951 M.2 SSD doesn't mess around either. Its sequential read and write speeds of 1,764MB/sec and 1,196MB/sec respectively are several times the speed of your average SATA SSD.

Thermal issues and fan noise are always a concern with small form factor machines, but the Chillblast didn't falter when running low-intensity tasks. Its CPU and GPU

1 **The Radeon R9 Nano card measures just 6in across**

2 **A Corsair H75 liquid cooler chills the overclocked CPU**

3 **The Metis' brushed-metal finish is immaculate**

remained cool and the fans were almost silent. The Fusion was barely any louder when we ran game tests, and heat wasn't an issue either – the CPU and GPU delta Ts of 42°C and 51°C are impressive for such a small machine. The fans were a little noisier when running games, though, and close inspection revealed a bit of the high-pitched capacitor whine common with Fury Nano cards. It was never irritatingly noisy though; even quiet gaming audio will drown it out.

The hottest thermal results were recorded when its GPU and CPU were both running at full load. The CPU delta T of 73°C was particularly high, and the fans then ramped up and churned out more noise. Even so, you're very unlikely to run both the CPU and GPU at full pelt for long periods, and the temperatures are still within thermal limits. However, we advise leaving plenty of airflow space around the Fusion so that its fans get a decent supply of air.

Conclusion

Small form factor PCs always involve compromise, but Chillblast's Fusion Nano comes close to replicating a full-sized system in benchmarks. The stupendous Nano card provides more graphics power than we've ever seen from such a small graphics card, and the Core i7 CPU is quick too.

Meanwhile, the chassis looks good and is organised as tidily as possible, although it comes with the usual mini-ITX caveats: a lack of upgrade room and hot running at full load.

It's also a little more expensive than full-sized machines that offer similar power, and you can save money by building your own machine with a similar spec too (see p84). However, building a custom rig from scratch isn't for everyone, and if you're looking for an attractive, well-built miniature PC that still offers storming performance, the Fusion Nano is a great example.

MIKE JENNINGS

CPC REALBENCH 2015

GIMP IMAGE EDITING

HANDBRAKE H.264 VIDEO ENCODING

LUXMARK OPENCL

HEAVY MULTITASKING

SYSTEM SCORE

INTEL REFERENCE: 126.43%

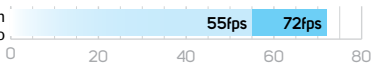
BATTLEFIELD 4

2,560 x 1,440, Ultra Detail, 4x AA

3,840 x 2,160, Ultra Detail, 4x AA

SHADOW OF MORDOR

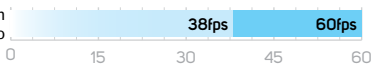
2,560 x 1,440, Ultra Detail, FXAA



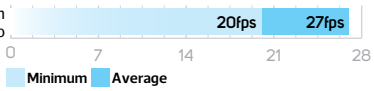
3,840 x 2,160, Very High Detail, FXAA

CRYSIS 3

2,560 x 1,440, Very High Detail, 0x AA



3,840 x 2,160, Very High Detail, 0x AA



Minimum Average

SPEED	DESIGN	OVERALL SCORE
23/25	23/25	88%
HARDWARE	**VALUE**	
22/25	20/25	

VERDICT

An amazing amount of power inside a surprisingly small package, thanks to AMD's Fury Nano card.

GAMING PC

Box Cube Predator / £1,999 inc VAT

SUPPLIER www.box.co.uk

This system from Birmingham-based builder Box is one of the largest PCs we've ever seen. The Corsair Graphite 780T weighs 11kg on its own and stretches 637mm from its base to its roof – and those dimensions, and the black and white colour scheme ensures it will stand out like a monolith in any room.

The Predator takes up more space than your average desktop rig, but the case is also practical. The front and top panels are made of mesh and pop off for easy fan access, and the chassis sits on large feet that allow plenty of airflow into the base. Both side panels ease off with handles rather than fiddly screws, and the front panel has four USB ports and a fan-speed switch.

The Graphite is no less impressive on the inside. The front half of the chassis has five free hard disk bays with tool-free caddies that are divided into two removable cages. Further back, there's a huge motherboard tray with rubber-lined routing holes and ample room for cables. Around the back you'll find three vacant 2.5in bays, while cooling is handled by two 140mm fans at the front and a 140mm exhaust unit.

The Predator is a full-sized ATX build, but the components are dwarfed by the sheer size of the case. There's plenty of clearance between the bottom of the motherboard and the large, modular PSU, and the Corsair Hydro H110i GT cooler installed in the roof isn't even visible.

It's a good-looking rig too. The black and white theme is carried over to the interior, where the MSI motherboard uses both colours liberally. Every other component matches the scheme – even the M.2 SSD and memory are black and white.

The Predator is tidy, well made and has loads of room for working inside, but we still can't help but think of what could have been. The off-the-shelf water-cooling unit, lack of sleeved cables and an absence of illumination are all obvious, especially given the side panel's huge window. There's a huge amount of room to grow here, but the end result seems underwhelming because of this case's size and the machine's price.

Meanwhile, gaming power comes from an MSI GeForce GTX 980 Ti card, which overclocks the GPU base clock from 1GHz to 1102MHz, boosting to 1190MHz. It's chilled by two smart, industrial-looking fans, and its 6GB of GDDR5 memory runs at 7010MHz. If you'd like more gaming power, Box also produces an SLI version of this machine, which will set you back £2,800 inc VAT.

The Predator is also equipped with Intel's Core i7. It's the most powerful Skylake part, with four Hyper-Threaded cores and plenty of cache, and Box has overclocked it from 4GHz to 4.5GHz with a 1.3V vcore. The rest of the specification is similarly impressive. There's 16GB of Kingston DDR4 memory that whizzes along at 3000MHz, and there's a Kingston M.2 SSD alongside a 4TB hybrid hard disk. There's also a Blu-ray writer.

The MSI Z170A Krait Gaming motherboard is generally decent too. It looks great, and has spare PCI-E slots – you could easily add another graphics card later. That said, it's missing some high-end options; there are no on-board buttons or an error readout, for example, and it doesn't have on-board lighting like other MSI Krait boards.

Finally, the standard Box two-year warranty includes collect and return coverage, of both parts and labour, which covers the essentials – the most important part of any warranty is the parts coverage, after all.

Performance

The overclocked GTX 980 Ti swept through our games tests. Its Battlefield 4 and Middle Earth: Shadow of Mordor minimums of 68fps and 70fps indicate that games at 2,560 x 1,440 aren't any problem for this GPU, and the Predator returned a swift minimum of 47fps in Crysis 3 as well. The GTX 980 Ti proved adept in most of our 4K tests too, although it struggled in Crysis 3 with a minimum of 22fps.

Meanwhile, the overclocked Core i7 has enough power to handle virtually all computing tasks, with the Box delivering an overall RealBench result of 145,525. That's 27 per cent quicker than our reference machine, and is in the usual league for an overclocked Core i7-6700K PC.

The Box continued to perform speedily in storage tests, but its Kingston M.2 SSD couldn't quite keep up with the Samsung hardware inside the Scan 3XS Z170 Vengeance (see Issue 145, p66). The HyperX drive's sequential read and write results of 1,411MB/sec and 653MB/sec are great, but

/SPECIFICATIONS

CPU 4GHz Intel Core i7-6700K overclocked to 4.5GHz

Motherboard MSI Z170A Krait Gaming

Memory 16GB Kingston HyperX 3000MHz DDR4

Graphics MSI GeForce GTX 980 Ti 6GB

Storage 240GB Kingston HyperX Predator M.2 SSD; 4TB Seagate hybrid hard disk

Case Corsair Graphite 780T Graphite Series

Cooling CPU: Corsair Hydro H110i GT with 2 x 120mm fans; GPU: 2 x 100mm fans; front: 2 x 140mm fans; rear: 1 x 140mm fan

PSU Seasonic SnowSilent 80 Plus Platinum 750W

Ports Front: 2 x USB 3, 2 x USB 2, 2 x audio; rear: 6 x USB 3.1, 2 x USB 2, 1 x Gigabit Ethernet, 1 x PS/2, 1 x optical S/PDIF, 5 x audio

Operating system Windows 10 Home 64-bit

Warranty Two years collect and return, covering parts and labour

1 **The 750W Seasonic SnowSilent PSU is 80 Plus Platinum rated and very quiet**

2 **The empty space in the chassis gives the hardware room to breathe**

3 **The MSI GeForce GTX 980 Ti card has a 1102MHz GPU base clock**

the Scan machine topped out at 1,928MB/sec and 1,120MB/sec – either way, you're unlikely to notice the difference in general use.

The Box machine outpaced most of its rivals in thermal tests, though. The CPU and GPU delta Ts of 40°C and 54°C respectively are both excellent, showing the advantage of giving hardware room to breathe in a large case. The same goes for the noise levels. The Box makes almost no noise when idle on the lowest fan setting. What's more, at this setting, you can still run games and the temperatures only increase by a couple of degrees. The 750W Seasonic SnowSilent PSU also helps here – it's very efficient (80 Plus Platinum, no less) and very quiet – its fan doesn't even spin up until it hits a 45 per cent load.

Conclusion

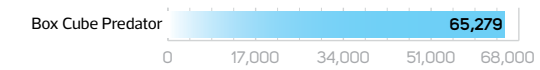
The Box Cube Predator has ample room to grow inside, and its overclocked components deliver performance levels that swipe aside most games and applications. Also, while the components and cooling system arguably don't make full use of the luxurious, versatile case, it's very cool and quiet.

The main problem for the Cube Predator is its price compared with the competition. You can specify the aforementioned Scan 3XS Z170 Vengeance with an EVGA GTX 980 Ti card for £1,741 inc VAT, for example, and while it might not have the Box's fancy PSU, swanky case and larger Corsair cooler, it's significantly cheaper and offers similar performance. If a cool and quiet system is your priority, though, the Predator is still well worth considering if you have the money.

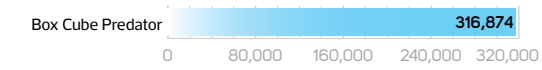
MIKE JENNINGS

CPC REALBENCH 2015

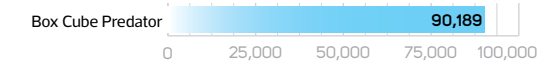
GIMP IMAGE EDITING



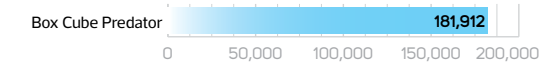
HANDBRAKE H.264 VIDEO ENCODING



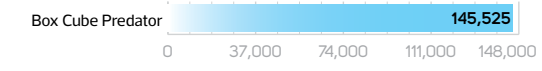
LUXMARK OPENCL



HEAVY MULTITASKING



SYSTEM SCORE



INTEL REFERENCE: 127.15%

BATTLEFIELD 4

2,560 x 1,440, Ultra Detail, 4x AA

3,840 x 2,160, Ultra Detail, 4x AA

SHADOW OF MORDOR

2,560 x 1,440, Ultra Detail

3,840 x 2,160, Ultra Detail, 4x AA

CRYSIS 3

2,560 x 1,440, Very High Detail, 0x AA

3,840 x 2,160, Very High Detail, 0x AA

Minimum Average

SPEED 23/25

DESIGN 22/25

HARDWARE 23/25

VALUE 19/25

OVERALL SCORE 87%

VERDICT

Fast, well built, cool and quiet, although it's comparatively expensive.

GAMING PC

Oblivion Gladiator / £1,200 inc VAT

SUPPLIER www.oblivionsystems.co.uk

Newcomer Oblivion has opted for an eye-catching black and orange colour scheme for the Gladiator, and it looks attractive with its large swathes of colour and little details. The pipes that flow down from the Raijintek Triton's 240mm reservoir are filled with orange coolant. Meanwhile, the Gigabyte motherboard mixes its black PCB with orange heatsinks, and the trio of intake fans and single exhaust spinner have all been replaced with orange-bordered Alpenföhn models. It's a great effort at colour coordination.

Likewise, the motherboard and graphics power cables are individually sleeved in orange, and the memory has been chosen for its heatsinks. Oblivion has fitted a smart nameplate to the shroud that covers the PSU at the base of the chassis as well, and a strip of orange LEDs illuminates the interior through the side panel's sizeable window.

It's all built into an NZXT H440 case, which is a great chassis in terms of both looks and features. It has four drive bays free behind the metal plate on the right, which does a great job of hiding cable clutter, but also means you have to remove the right side panel to access the bays. There are also two free 2.5in bays on the top of the PSU shroud, which also does a great job of hiding cable clutter. The end result is a tidy-looking machine.

The Gigabyte motherboard is a decent model too. The top-right corner sports a POST code display, and buttons that handle power, reset and overclocking, with buttons to toggle the CPU ratio and base clock level on the board itself. It also has toggles for activating or switching off memory slots and PCI-E slots.

Elsewhere, the board has three spare 16x PCI-E slots, a free PCI slot and one vacant 1x PCI-E slot, along with plenty of empty SATA and USB connectors. There's a PCI-E power plug above the graphics card for giving multi-GPU setups added current too. There's no M.2 port on-board, but the Z97 chipset won't get the most out of an NVMe M.2 SSD anyway.

The quad-core Core i5-4690K CPU is overclocked to 4.3GHz. It's a last-gen chip, with Skylake silicon taking over, but it's still powerful enough for most people's needs. The overclock isn't that ambitious, though, considering that other system builders have extracted 4.5GHz or 4.6GHz from the same silicon. It's paired with an Asus GeForce GTX 970 Strix graphics card, with two large fans, and a factory overclock, taking the GPU core from 1050MHz to 1114MHz.

There's also a solid allocation of 16GB of DDR3 memory, which is plenty for most people. It's only clocked at 1600MHz, though, when much faster memory is available for not much more money. That said, memory speed doesn't make a massive difference to overall performance. The 250GB Samsung 850 Evo SSD is a good SATA model too, but it seems pretty ordinary when compared with the quicker M.2 drives arriving with Skylake systems.

The specification doesn't look as strong when lined up against rivals though. The Overclockers Titan Riptide (see Issue 146, p68), for example, costs a similar price to this machine but includes a 6-core Intel processor and 16GB of memory clocked to 2400MHz, although it lacks the fancy liquid-cooling system. Scan's 3XS Z170 Vengeance system is a little more expensive than Oblivion's machine, but it justifies the extra pennies with a lightning-quick SSD and GTX 980 graphics.

Oblivion packages this PC with a two year return-to-base warranty that also includes parts and labour coverage for the same amount of time.

Performance

The Oblivion's key competitor is the Overclockers Titan Riptide, and the two machines make for an interesting comparison in our application benchmarks. The overclocked Core i5 part inside the Gladiator has a big clock speed advantage over the Haswell-E chip inside the Riptide, giving it the edge in our mostly single-threaded image editing test.

However, the six cores inside the Overclockers machine and the lack of Hyper-Threading inside the Gladiator saw the Riptide pull ahead in our heavily multi-threaded H.264 video encoding test. The Gladiator's end system score of 102,419 shows that it will be fine for most tasks and gaming, but it's a little underwhelming from a system that costs £1,200 inc VAT.

The Gladiator was great in gaming at both 1080p and 2,560 x, 1,440 too, never dropping below 30fps in any of our game tests. However, the machine arrived as pictured with the card installed in the second 16x PCI-E slot down, which only allocates eight lanes to it – an odd move, but Oblivion says it allows more room for tubing, pointing out that the GTX 970 won't saturate the bandwidth of eight lanes anyway. It isn't an optimal situation, but it does indeed have little effect on the GTX 970's performance. The 240GB Samsung SSD returned sequential read and write speeds of 497MB/sec

/SPECIFICATIONS

CPU 3.5GHz Intel Core i5-4690K overclocked to 4.3GHz

Motherboard Gigabyte GA-Z97X-SOC

Memory 16GB Team Vulcan 1600MHz DDR3

Graphics Asus GeForce GTX 970 4GB

Storage 250GB Samsung 850 Evo SSD; 1TB Western Digital hard disk

Case NZXT H440

Cooling CPU: Raijintek Triton with 2 x 120mm fans; GPU: 2 x 92mm fans; front: 3 x 120mm fans; rear: 1 x 120mm fan

PSU 650W SuperFlower Golden Green HX

Ports Front: 2 x USB 3, 2 x USB 2, 2 x audio; Rear: 4 x USB 3, 4 x USB 2, 1 x Gigabit Ethernet, 1 x PS/2, 1 x optical S/PDIF, 6 x audio

Operating system Windows 10 Home 64-bit

Warranty Two year parts and labour return to base

1 The Raijintek Triton all-in-one liquid cooler is filled with orange coolant

2 A smart Oblivion nameplate adorns the shroud covering the PSU area

3 The MSI GeForce GTX 970 graphics card plays all games at 2,560 x 1,440

and 478MB/sec, which are fine for a SATA SSD, but there's an obvious speed benefit from the M.2 NVMe drives we're seeing with Skylake and X99 machines now.

We didn't encounter any thermal issues with the Oblivion either. Its CPU and GPU delta Ts of 54°C and 52°C are fine, and noise levels were consistent – when idle, the machine churned out a low hum, and that noise only increased a little when we played games – you won't notice the rumble if you use speakers or a headset. There's a also fan controller on the back, but it just ramped up the fan noise to uncomfortable levels, and our tests indicated that the CPU didn't overheat with the fans running at a more modest pace anyway.

Conclusion

The Gladiator system has clearly been built carefully. The orange and black colour scheme has been cleverly applied throughout virtually every component, and the little touches show that Oblivion has really thought about the looks and build of its first review machine.

The Core i5 CPU and overclocked GPU offer decent enough gaming and application performance, and the motherboard is packed with features as well. It's a shame, then, that this PC is let down in some other departments. The reliance on a last-generation motherboard and CPU, comparatively slow memory and SATA storage all make it look uncompetitive next to similarly priced X99 and Skylake machines. Nevertheless, Oblivion is clearly a company to watch in the enthusiast system arena, and we look forward to seeing what else it can do.

MIKE JENNINGS

CPC REALBENCH 2015

GIMP IMAGE EDITING

HANDBRAKE H.264 VIDEO ENCODING

LUXMARK OPENCL

HEAVY MULTITASKING

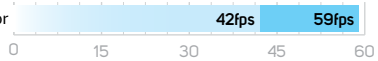
SYSTEM SCORE

INTEL REFERENCE: 89.49%

BATTLEFIELD 4

1,920 x 1,080, Ultra Detail, 4x AA

2,560 x 1,440, Ultra Detail, 4x AA



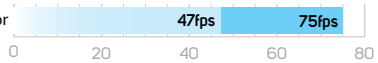
SHADOW OF MORDOR

1,920 x 1,080, Ultra Detail, FXAA

2,560 x 1,440, Ultra Detail, FXAA

CRYSIS 3

1,920 x 1,080, Very High Detail, 0x AA



2,560 x 1,440, Very High Detail, 0x AA

Minimum Average

SPEED	DESIGN	OVERALL SCORE
20/25	23/25	84%
HARDWARE	VALUE	
20/25	21/25	

VERDICT

Great looks and reasonable power, but the specification is a little too inconsistent to earn a wholehearted recommendation.

Elite

Our choice of the best hardware available

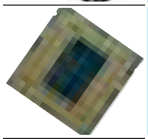
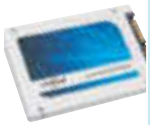
Build a mini APU PC

The parts you'll need to build an affordable, general-purpose mini PC that's ideal for putting in the lounge, based on an AMD APU. This machine will handle general computing and media tasks with no trouble, as well as basic gaming, although you'll have to lower the detail settings.

	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	SilverStone Fortress FTZ01	www.scan.co.uk	Issue 144, p84	£110
	Gigabyte F2A88XN-WiFi	www.cclonline.com	Issue 144, p84	£81
	AMD A10-7870K	www.scan.co.uk	Issue 144, p22	£104
	8GB Corsair Vengeance Pro 2400MHz (CMY8GX3M2A2400C11R)	www.scan.co.uk	Issue 144, p84	£44
	Cooler Master Seidon 120V	www.scan.co.uk	Issue 144, p84	£39
	250GB Crucial BX100	www.scan.co.uk	Issue 144, p84	£69
	SilverStone SST-ST30SF	www.scan.co.uk	Issue 144, p84	£41
	Microsoft Windows 10 Home Retail USB drive	www.scan.co.uk	Issue 146, p17	£88
			TOTAL	**£576**

Build a budget gaming PC

The parts you'll need to build a budget machine capable of playing the latest games at maximum settings on a 1080p monitor. The machine has a discrete graphics card, a highly overclockable dual-core CPU and high-speed memory. Meanwhile, the Z97 motherboard gives you headroom to upgrade to a faster CPU later.

	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	NZXT S340	www.overclockers.co.uk	Issue 137, p54	£60
	ASRock Z97 Pro3	www.scan.co.uk	Issue 130, p50	£73
	Intel Pentium G3258	www.scan.co.uk	Issue 132, p17	£52
	8GB Corsair Vengeance Pro 2400MHz DDR3 (CMY8GX3M2A2400C11R)	www.scan.co.uk	Issue 132, p22	£44
	Asus GeForce GTX 950 Strix UPDATED	www.ebuyer.co.uk	Issue 147, p20	£139
	250GB Crucial BX100	www.scan.co.uk	Issue 144, p84	£69
	SilverStone Argon AR01	www.scan.co.uk	Issue 132, p57	£26
	EVGA SuperNova GS 550W	www.dabs.com	Issue 146, p50	£57
	Seagate Barracuda 2TB ST2000DM001	www.scan.co.uk	Issue 104, p75	£55
	Microsoft Windows 10 Home Retail USB drive	www.scan.co.uk	Issue 146, p17	£88
			TOTAL	£663

Build a mid-range PC

Work PC

The parts you'll need to build a solid quad-core PC with plenty of upgrade potential. This kit list gives you an all-in-one liquid cooler and a K-series Core i5 Skylake CPU, meaning you can overclock it and get some serious processing power. We've managed to get the Core i5-6600K Skylake CPU up to 4.6GHz, so it has some great performance potential. Also included is a solid EVGA PSU, a 500GB SSD and 8GB of high-speed DDR4 memory. The core configuration assumes you won't be doing any serious gaming, however, and it relies on Intel's integrated graphics.

	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	NZXT Phantom 530	www.overclockers.co.uk	Issue 127, p44	£98
	Asus Maximus VIII Ranger UPDATED	www.ebuyer.com	Issue 147, p44	£154
	Intel Core i5-6600K	www.scan.co.uk	Issue 145, p17	£198
	8GB Corsair Vengeance LLPX 2666MHz DDR4 (CMK8GX4M2A2666C16)	www.scan.co.uk	Issue 145, p24	£51
	NZXT Kraken X41	www.overclockers.co.uk	Issue 138, p57	£73
	EVGA SuperNova GS 550W	www.dabs.com	Issue 146, p50	£57
	Seagate Barracuda 2TB ST2000DM001	www.scan.co.uk	Issue 104, p75	£55
	Lite-On IHAS124-14	www.dabs.com	Issue 99, p108	£11
	Crucial BX100 500GB	www.ebuyer.com	Issue 141, p43	£135
	Microsoft Windows 10 Home Retail USB drive	www.scan.co.uk	Issue 146, p17	£88
			TOTAL	£920

Gaming PC

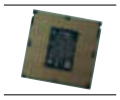
The graphics card you'll need to play current games at their maximum settings at 1080p and 2,560 x 1,440.

	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	**1,920 x 1,080** Asus GeForce GTX 950 Strix UPDATED	www.ebuyer.co.uk	Issue 147, p20	£139
	**2,560 x 1,440** Nvidia GeForce GTX 970 4GB	www.scan.co.uk	Issue 140, p48	£252

Build a performance PC

Work PC

The parts you'll need to build a high-quality, fast PC that's ideal for multi-threaded workloads. This kit list features a high-quality, well-built case, a feature-rich motherboard and an Intel Skylake Core i7-6700K CPU. This processor's support for Hyper-Threading splits the resources of the CPU's four physical cores into a further four virtual cores, meaning it can effectively handle eight threads at once. There's also a solid Corsair 750W PSU, giving you plenty of headroom for overclocking and adding another GPU, 16GB of DDR4 memory and an all-in-one liquid cooler.

	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	Cooler Master Cosmos SE	www.cclonline.com	Issue 144, p41	£120
	Asus Maximus VIII Hero	www.novatech.co.uk	Issue 146, p20	£170
	Intel Core i7-6700K	www.scan.co.uk	Issue 145, p17	£319
	16GB Corsair Vengeance LLPX 2666MHz DDR4 (CMK16GX4M2A2666C16)	www.scan.co.uk	Issue 145, p24	£90
	NZXT Kraken X41	www.overclockers.co.uk	Issue 138, p57	£73
	Corsair RM750i	www.scan.co.uk	Issue 146, p55	£104
	Seagate Barracuda 2TB ST2000DM001	www.scan.co.uk	Issue 104, p75	£55
	Samsung 850 Evo 500GB	www.scan.co.uk	Issue 141, p51	£138
	Microsoft Windows 10 Home Retail USB drive	www.scan.co.uk	Issue 146, p17	£88
			TOTAL	£1,157

Gaming PC

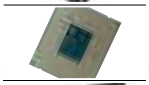
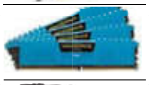
The graphics card you'll need to play current games at their maximum settings at 2,560 x 1,440 and beyond.

	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	**2,560 x 1,440** Nvidia GeForce GTX 970 4GB	www.scan.co.uk	Issue 140, p48	£252
	**4K** 2 x Nvidia GeForce GTX 970 4GB	www.scan.co.uk	Issue 140, p50	£504

Build a 6-core workstation

Multi-threaded workstation

The parts you'll need to build a PC with serious power in multi-threaded workstation software, such as 3D rendering apps and optimised distributed computing software. The kit list features a 6-core LGA2011-v3 CPU, which is overclockable using the motherboard and cooler listed. Also supplied is 16GB of RAM, 1TB of solid state storage and a 1.2kW PSU, providing loads of headroom for adding multiple GPUs.

	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	Phanteks Enthoo Luxe	www.eclipsecomputers.com	Issue 144, p53	£117
	Asus X99 Deluxe	www.overclockers.co.uk	Issue 136, p20	£315
	Intel Core i7-5820K	www.scan.co.uk	Issue 134, p43	£309
	Asus GeForce GTX 950 Strix	www.ebuyer.co.uk	Issue 147, p20	£139
	16GB Corsair Vengeance LPX 2666MHz DDR4 (CMK16GX4M4A2666C16)	www.scan.co.uk	Issue 136, p14	£108
	Corsair Hydro H110i GT	www.eclipsecomputers.com	Issue 140, p17	£93
	Corsair Professional Series AX1200i	www.scan.co.uk	Issue 111, p40	£253
	Samsung 850 Evo 1TB	www.cclonline.com	Issue 141, p51	£280
	Seagate Barracuda 2TB ST2000DM0001	www.scan.co.uk	Issue 104, p75	£55
	Lite-On IHAS124-14	www.dabs.com	Issue 99, p108	£11
	Microsoft Windows 10 Home Retail USB drive	www.scan.co.uk	Issue 146, p17	£88
			TOTAL	£1,768

4K gaming PC

This LGA2011-v3 system can support multiple graphics cards over 28 PCI-E 3 lanes, making it an ideal foundation for high-resolution PC gaming, replacing the graphics card listed above with two high-spec cards.

	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	**4K** 2 x Nvidia GeForce GTX 970 4GB	www.scan.co.uk	Issue 140, p50	£504
			TOTAL	£2,133

Build a mini PC

Core components

The parts you'll need to build either PC. This kit list gives you a solid PSU, 16GB of RAM, an overclockable Skylake CPU, an all-in-one liquid cooler and Windows 10 Home 64-bit. Also included is a short-PCB graphics card that can play current games at their maximum settings at 2,560 x 1,440, and a 500GB SSD.

	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	Intel Core i7-6700K UPDATED	www.scan.co.uk	Issue 147, p84	£319
	16GB (2 x 8GB) Corsair Vengeance LPX 2666MHz UPDATED	www.scan.co.uk	Issue 147, p84	£90
	Corsair H80i GT UPDATED	www.scan.co.uk	Issue 147, p84	£80
	Asus GeForce GTX 970 DirectCU Mini	www.overclockers.co.uk	Issue 139, p20	£300
	Crucial BX100 500GB	www.ebuyer.com	Issue 141, p43	£135
	Seagate Barracuda 2TB ST2000DM001	www.scan.co.uk	Issue 104, p75	£55
	Lite-On IHAS124-14	www.dabs.com	Issue 99, p108	£11
	EVGA SuperNova GS 550W	www.dabs.com	Issue 146, p50	£57
	Microsoft Windows 10 Home Retail USB drive	www.scan.co.uk	Issue 146, p17	£88

Mini-ITX PC

The parts you'll need to build a pint-sized powerhouse.

	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	Corsair Obsidian 250D	www.scan.co.uk	Issue 136, p41	£75
	Asus Z170i Pro Gaming UPDATED	www.cclonline.com	Issue 147, p26	£130
			TOTAL	£1,340

Micro-ATX PC

The parts you'll need to build a mini PC that doesn't take up as much room as a full-sized desktop.

	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	Fractal Design Arc Mini R2	www.scan.co.uk	Issue 127, p46	£67
	Asus Maximus VIII Gene UPDATED	www.scan.co.uk	Issue 147, p42	£142
			TOTAL	£1,344

Cases

	TYPE	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	**Budget ATX**	NZXT S340	www.overclockers.co.uk	Issue 137, p54	£60
	**Sub-£100 ATX quiet**	Fractal Design Define R5	www.scan.co.uk	Issue 137, p20	£79
	**Sub-£100 ATX performance**	NZXT Phantom 530	www.overclockers.co.uk	Issue 127, p44	£98
	**Sub-£150 full-sized ATX quiet**	Nanoxia Deep Silence 5	www.quietpc.com	Issue 144, p50	£113
	**Sub-£150 full-sized ATX**	Phanteks Enthoo Luxe	www.eclipsecomputers.com	Issue 144, p53	£117
	**Sub-£150 mid-size ATX**	Cooler Master Cosmos SE	www.cclonline.com	Issue 144, p41	£120
	**Mini-ITX tower**	Corsair Obsidian 250D	www.scan.co.uk	Issue 136, p41	£75
	**Mini-ITX cube**	Antec ISK600	www.overclockers.co.uk	Issue 126, p28	£45
	**Micro-ATX**	Fractal Design Arc Mini R2	www.scan.co.uk	Issue 127, p46	£67
	**Water-cooling micro-ATX**	Parvum Systems S2.0	www.overclockers.co.uk	Issue 129, p22	£140

Graphics cards

	TYPE	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	**1,920 x 1,080 gaming**	Asus GeForce GTX 950 Strix UPDATED	www.ebuyer.co.uk	Issue 147, p20	£139
	**2,560 x 1,440 gaming**	Nvidia GeForce GTX 970 4GB	www.scan.co.uk	Issue 140, p48	£252
	**High-end single-GPU gaming**	EVGA GeForce GTX 980 Ti Classified ACX 2.0+ UPDATED	www.scan.co.uk	Issue 147, p24	£619
	**4K gaming**	2 x Nvidia GeForce GTX 970 4GB	www.scan.co.uk	Issue 140, p49	£504
	**Mini-ITX**	Asus GeForce GTX 970 DirectCU Mini	www.overclockers.co.uk	Issue 139, p20	£300

Power supplies

	TYPE	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	**Mid-range 550W**	EVGA SuperNova GS 550W	www.dabs.com	Issue 146, p50	£57
	**High-end 550W**	Super Flower Leadex Platinum 550W	www.overclockers.co.uk	Issue 146, p52	£83
	**Mid-range 750W**	Corsair RM750i	www.scan.co.uk	Issue 146, p55	£104
	**High-end 1.2kW**	Corsair Professional Series AX1200i	www.scan.co.uk	Issue 111, p40	£253

Networking

	TYPE	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	**Router**	Asus RT-AC68U	www.scan.co.uk	Issue 128, p88	£139
	**Wi-Fi adaptor**	Asus PCE-AC68	www.scan.co.uk	Issue 128, p88	£67

Storage

	TYPE	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	**Hard disk**	Seagate Barracuda 2TB ST2000DM001	www.scan.co.uk	Issue 104, p75	£55
	**250GB SSD**	Crucial BX100 250GB	www.scan.co.uk	Issue 141, p43	£69
	**500GB SSD**	Crucial BX100 500GB	www.ebuyer.com	Issue 141, p43	£135
	**1TB SSD**	Samsung 850 Evo 1TB	www.cclonline.com	Issue 141, p51	£280
	**High-performance SSD**	Intel SSD 750 1.2TB	www.scan.co.uk	Issue 143, p24	£809
	**NAS box**	Synology DS215J	www.cclonline.com	Issue 138, p17	£134

Monitors

	TYPE	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	**24in monitor**	Dell U2414H	www.overclockers.co.uk	Issue 129, p43	£186
	**29in monitor**	Asus PB298Q	www.scan.co.uk	Issue 129, p52	£293
	**28in 4K monitor**	Asus PB287Q	www.scan.co.uk	Issue 133, p44	£383
	**G-Sync monitor**	Asus ROG Swift PG278Q	www.eclipsecomputers.com	Issue 143, p44	£552
	**FreeSync monitor**	BenQ XL2730Z	www.overclockers.co.uk	Issue 143, p46	£390

Peripherals

	TYPE	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	**Budget mechanical keyboard**	Gigabyte Aivia Osmium	www.awd-it.co.uk	Issue 139, p40	£65
	**Mechanical gaming keyboard**	CM Storm Trigger-Z	www.ebuyer.com	Issue 139, p44	£70
	**Mechanical MMO keyboard**	Corsair Vengeance K95	www.awd-it.co.uk	Issue 123, p64	£125
	**Gaming mouse**	Logitech G402 Hyperion Fury	www.currys.co.uk	Issue 139, p53	£40
	**Wireless gaming mouse**	SteelSeries Sensei Wireless	www.box.co.uk	Issue 139, p61	£90
	**Flight stick**	Saitek X-55 Rhino H.O.T.A.S.	www.overclockers.co.uk	Issue 131, p29	£170
	**Steering wheel and pedals**	Thrustmaster TX Ferrari 458 Italia Edition	www.overclockers.co.uk	Issue 137, p32	£300

Audio

	TYPE	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	**PCI-E sound card**	Creative Sound Blaster Z	www.eclipsecomputers.com	Issue 116, p42	£66
	**USB DAC**	Asus Xonar Essence One	www.overclockers.co.uk	Issue 118, p44	£363
	**2.1 speakers**	Acoustic Energy Aego M	www.amazon.co.uk	Issue 142, p52	£165
	**Soundbar**	Razer Leviathan	www.overclockers.co.uk	Issue 142, p57	£165
	**Headset**	HyperX Cloud II	www.ebuyer.com	Issue 142, p46	£70
	**Surround-sound headset**	Asus Strix 7.1	www.cclonline.com	Issue 142, p43	£150

Systems

	TYPE	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	**Sub-£1,000 gaming PC**	PC Specialist Hailstorm GT	www.pcspecialist.co.uk	Issue 146, p66	c. £899
	**Quiet gaming PC**	Chillblast Fusion Serenity	www.chillblast.co.uk	Issue 138, p66	c. £1,499
	**Dream PC**	Scan 3XS Barracuda	www.scan.co.uk	Issue 145, p58	c.£9,499
	**Sub-£2,000 gaming PC**	Scan 3XS X99 Carbon Ti	www.scan.co.uk	Issue 143, p58	c.£1,999
	**Skylake PC**	Scan 3XS Z170 Vengeance	www.scan.co.uk	Issue 145, p66	c. £1,449
	**Mini-ITX gaming PC**	Chillblast Fusion Fury Nano UPDATED	www.chillblast.co.uk	Issue 147, p56	£1,619
	**Gaming laptop**	MSI GT70 2PC Dominator	www.overclockers.co.uk	Issue 129, p26	c. £1,320
	**Premium PC**	Overclockers UK Infin8 Emperor	www.overclockers.co.uk	Issue 145, p44	c.£5,399

Games

Featured this month

RICK LANE / INVERSE LOOK

THE SECRET WORLD

The game industry's obsession with secrecy is pathetic, self-defeating and needs to stop, argues Rick Lane

The game industry is obsessed with secrecy. Publishers guard information about their games with the vigilance of a spy agency protecting an informant. Every detail revealed about a game in development is controlled by a marketing schedule stricter than a Victorian schoolmaster, and developers are kept silent by punitive non-disclosure agreements (NDAs) that can result in lawsuits if they let slip an inconsequential fact about a game at the wrong time.

Standard critical journalism practice, such as playing games prior to release in order to write a timely review, is becoming increasingly difficult to perform, as PR companies drip-feed review copies for maximum exposure over the longest time possible. Even specifying precisely when a game will become available for review is often too much to ask, which makes keeping a schedule almost impossible. Talking to developers has to be done in accordance to the grand marketing plan. Some publishers even refuse to talk about a game after it's been released, believing that it distracts from their focus on new projects.

> The silly thing is that transparency and criticism rarely affect sales of games

Of course, if the problems were restricted to making my life more difficult than necessary, I'd leave my griping for the pub. Yet the game industry's cloak-and-dagger approach to discussing games isn't just irritating for journalists, it's also harmful to developers.

While NDAs might seem sensible safeguards during game development, they often end up gagging developers for far longer. I commonly encounter designers who are reluctant to discuss projects they worked on ten or 20 years ago, for fear that an NDA they signed, or even *might* have signed, years back will come back to bite them in the bank account.

The culture of silence can make it hard for new devs to get into the industry too. Last year, music agent Darrell Alexander complained that the game industry's opacity regarding current projects made it very difficult to find jobs for freelance audio designers. Publishers could be missing out on amazing talent simply because nobody knows what they're making.

The silence also has more serious ramifications for developers, as it conceals the more insidious parts of the industry, such as poor management, abusive employment practices, or crunch, which I discussed last month. If developers are reluctant to talk about the *positive* aspects of their work for fear of legal reprisals, how can they address the negative aspects?

The reason the industry is so secretive isn't entirely clear, but it could be because it's grown up with a very vocal audience. The music, film and publishing industries all matured prior to the Internet, so criticism came mainly from newspapers and angry fans sending letters. But the game industry grew up attuned to an online audience, and gaming fans can be ferocious critics.

Yet rather than responding in the two most sensible ways, either sticking to its guns or making changes when criticism appears, the industry has instead decided to bury its head in the sand, only popping up to spit out a new game here and there. The silly thing is that transparency and criticism rarely affect sales. In 2012, almost every fact about Modern Warfare 3 was leaked onto the Internet prior to release, and yet the game still sold tens of millions of copies.

So open up, game industry. Let us talk to your developers, review your games on time and discuss your problems openly. We'll all feel better for it and you'll still be richer for it. CPC

Rick Lane is Custom PC's games editor. @Rick_Lane

Metal Gear Solid V: The Phantom Pain / £45 inc VAT

DEVELOPER Kojima Productions / **PUBLISHER** Konami / **WEBSITE** www.konami.jp/mgs5

OVERALL SCORE
95%

/ VERDICT
With astonishing attention to detail and flexibility in its systems, Metal Gear Solid V is the new pinnacle of stealth gaming.

The Metal Gear Solid series has always been a great innovator in terms of stealth mechanics and creative play. Until now, though, the games have also come with a hefty side order of cinematic storytelling; depending on the particular game, this was either a welcome accompaniment to those delightful stealth systems, or an infuriating distraction from them.

With the Phantom Pain, however, the lengthy cut-scenes and ponderous philosophising of its characters, previously hallmarks of the series, have been stripped back. Instead, the emphasis is on the player and their actions, which has two consequences. First, Metal Gear Solid V has one of the weakest stories in the series. Second, Metal Gear Solid V is the greatest stealth game ever.

Players reprise the role of Big Boss, the hero of Metal Gear Solid 3 and Peace Walker, and the antagonist of the original Metal Gear who was ultimately defeated by Solid Snake. Phantom Pain is about that transition from hero to villain. It's 1984, and Big Boss awakens from a coma after a disastrous covert operation nine years previously, which saw the obliteration of the private army he established in Peace Walker. After a dramatic and cinematic escape from the hospital where he's being treated, Big Boss takes it upon himself to rebuild his forces – the Diamond Dogs – and exact vengeance on those who attacked him nine years ago.

The game then lets you off its cinematic leash, parachuting you into two fantastic open worlds designed entirely around stealth gaming. To fund his army, Big Boss takes on private contracts, infiltrating dangerous conflict zones in Afghanistan and Zaire. These contracts include assassination missions, prisoner extractions, intelligence operations and all kinds of wetwork for various clients. Each of the game's 40-odd missions uses a chunk of these large environments, inserting you a fair distance from the objective by helicopter, and letting you work your way through guard posts and enemy patrols, approaching the objective however you please.

The standard top-down presentation has been jettisoned in favour of a more modern third-person perspective, while stealth is much more about choice and preparation than simply threading the needle in the correct manner. The military encampments, occupied villages and dozens of other target locations can be tackled from almost any angle, so you need to consider your approach carefully, marking guard patrols using your binoculars, and thoughtfully using weapons and equipment with care.

A vast array of factors affect the perception of your enemies, such as whether you're standing or crouching, the time of day, the type of camouflage you're wearing and whether you're positioned in light or shadow. Enemies have keen hearing too. Knock over an object and a nearby guard might investigate, while environmental sounds such as rainfall or passing vehicles can help mask your footsteps.

In many ways, the game becomes even more interesting when your plans go wrong. Being discovered by a guard triggers 'reflex' mode – a few seconds of slow motion in which Big Boss can dispatch his opponent before the









alarms sound. It's an ingenious way to both increase the tension and give the player one last chance to rectify their mistake. If you fail, the base is alerted to your presence, and you need to either evade the gunfire or fight back. As an action game, MGS V is less forgiving but equally compelling. You can use standard cover/fire tactics, and explosives such as grenades and rocket launchers, and even call in helicopter support.

Meanwhile, all your achievements are tied together by Mother Base, the Diamond Dogs headquarters that you expand as the game progresses. This sprawling oil rig in the Seychelles serves many functions, each r by a different platform. R&D, for example, dev weapons and gadgets, while the Intel and Sup platforms give you greater tactical options in t as more advanced helicopters and even the ab artillery fire.

Expanding Mother Base requires money an former you receive through completing missio side-ops and eventually sending troops on cor deployment. The latter are acquired through v and capturing enemy soldiers by knocking ther extracting them using 'Fulton balloons'. These balloons are attached to in-game objects, whic shooting into the sky to be collected by a helico you can upgrade your Fulton balloons to extrac gun placements, cargo containers and even tan

As you delve deeper into the game, your infilt capabilities increase exponentially. Mission bud as D-Dog let you sense enemy locations withou mark them manually, while gadgets such as sm grenades and 'decoys' – inflatable dummy versi yourself – enable more creative ways to distract incapacitate guards and patrols. Brilliantly, howe enemies will eventually adapt to your tactics. Us smoke grenades, and base guards will begin to v

masks. The game doesn't allow you to rely on one particular approach for too long. It constantly encourages you to adapt and experiment.

There are a few problems. It takes a while to get used to the keyboard controls, although it's worth it for the massive boon of mouse-aiming. The story, as previously mentioned, is also rather thin and scattered, with much of it squirreled away in audio logs that you can play while roaming the world. Big Boss is curiously mute for many of the more dramatic scenes, while antagonists such as Skull Face and the Man on Fire

Mad Max / £34.99 inc VAT

DEVELOPER Avalanche Studios / **PUBLISHER** Warner Bros / **WEBSITE** www.madmaxgame.com

Mad Max is an interesting case study for how radically the open-world game has changed in recent months. If it had been released a couple of years ago, it would have been one of the best open worlds we'd experienced. However, it's had the misfortune to launch in the same year as two exceptional open-world games – The Witcher 3 and Metal Gear Solid V. Both games have elevated the genre through their meticulous design around specific characters, with every aspect of the games carefully constructed to make sense within those worlds.

By comparison, Mad Max takes a specific theme and drapes it over a standard open-world framework, giving tried and tested mechanics and missions a lick of rust-coloured paint. The result is still a competent and occasionally spectacular open-world experience, but one that's visibly greying at the temples.

Avalanche's game begins with a fittingly simple premise. After having his Interceptor car stolen and destroyed by local warlord Scabrous Scrotus, Max teams up with a highly eccentric yet brilliant mechanic named Chumbucket to create the greatest car the Wasteland has ever seen – the Magnum Opus. To achieve this goal, Max must help Chumbucket source the best parts the Wasteland has to offer, which means travelling to its farthest reaches and making a bunch of fragile alliances with dangerous people.

The story is distinctly no-frills, but the script is surprisingly well written. Chumbucket in particular is a fantastic character, a quirky hunchback who loves cars so much he's built his own religion around them. He talks about vehicles with the flowery oration of a priest, and refers to people with the cold technical jargon of a mechanic. The various warlords you encounter on your travels have equally colourful personalities. In fact, the only letdown is Max himself who, despite having a better Australian accent, lacks that barely contained mixture of rage and grief that Tom Hardy depicts so well in the recent film, Fury Road.

As with most open-world games, the best character is the Wasteland itself, which is as beautiful as it is eerie. It's also surprisingly varied. Avalanche has painstakingly ensured that each of its regions feels unique, ranging from sweeping sand dunes and parched salt flats to a vast, blackened rubbish dump that forms the outskirts of Gastown, the player's ultimate destination. But even in the most desolate parts of the waste, there's always something on screen to draw your eye. It might be a unique rock formation, a towering 'scarecrow' totem pole, or a curiously repurposed fragment of civilisation, such as a concrete cooling tower that's been converted into a warlord's fortress.

It's a strange, harsh world that's evidently dying around you, yet it still manages to lash out angrily during these death throes. Punishing dust storms thunder into the game with the force of a tidal wave, flinging debris at you like a child throwing a tantrum. Meanwhile, you're constantly harassed by War parties that roam the sands, preying on the weak and vulnerable.

It's during encounters with these roving vehicular bandits where Mad Max shines brightest. Car combat is a truly fearsome whirlwind of fire and twisted metal. You can approach it straightforwardly, ramming and side-slamming into other vehicles until they explode in viscous flames. Or you can be more surgical, using your harpoon gun to yank wheels, doors and even drivers from their vehicles. It's thrilling and inventive, making good use of the Wasteland's meandering roads and rugged landscapes.

The only problem with the car combat is that, bizarrely, the game doesn't place much emphasis on it. Far more time is spent fighting your enemies on foot, which simply isn't as entertaining. The melee combat is functional and works thematically, taking the free-flow combat system seen in Batman: Arkham Asylum and giving it a scrappier edge, but it isn't interesting enough to justify the amount of time the game dedicates to it.

In fact, Mad Max generally doesn't have its priorities straight. The open-world activities in which you partake feel like template distractions with a post-apocalypse theme, rather than activities tailored specifically to what makes Mad Max interesting. For example, a big chunk of your time is spent raiding fortified oil transfer camps that belong to Scrotus – a spin on the 'base liberation' side quest that's a staple in open-world games such as Far Cry. Yet rather than encouraging creative play with the game's systems, as in Far Cry, raiding these camps in Mad Max means performing the same sequence of actions over and over again.

The game attempts to tie these disparate activities together through the process of upgrading the Magnum Opus. Many story missions require you to have obtained particular parts for your car, and often those parts are only unlocked by completing a certain number of side activities. However, it's presented in a confusing and off-putting manner. It's possible to race ahead with the story, only to have to backtrack for several hours mopping up occupational detritus in order to unlock a better exhaust or a more powerful engine.

Every task in the game takes longer than necessary. Raiding transfer camps is unnecessarily drawn out by cut-and-paste obstacles, collecting scrap (the game's currency for buying upgrades) is a painfully slow process. Every fistfight is two or three minutes longer than necessary, and there are times when you need a flowchart to figure out what you need in order to unlock the next story mission.

Consequently, the game's pacing is extremely uneven. There are times when you feel like you're racing towards completion, and other times where you're overwhelmed by the sheer amount of work required to make any progress whatsoever. In the end, Mad Max the game has a lot in common with Mad Max the character. When it comes to surviving in a brutal, desolate wasteland and fighting off War Parties through bone-crunching vehicular combat, Mad Max excels. But when it comes to doing anything else, the game simply struggles to cope.

RICK LANE

OVERALL SCORE
64%

/ VERDICT
Exhilarating car combat and a beautiful open world are wasted on a game that isn't worth the time and investment that's required.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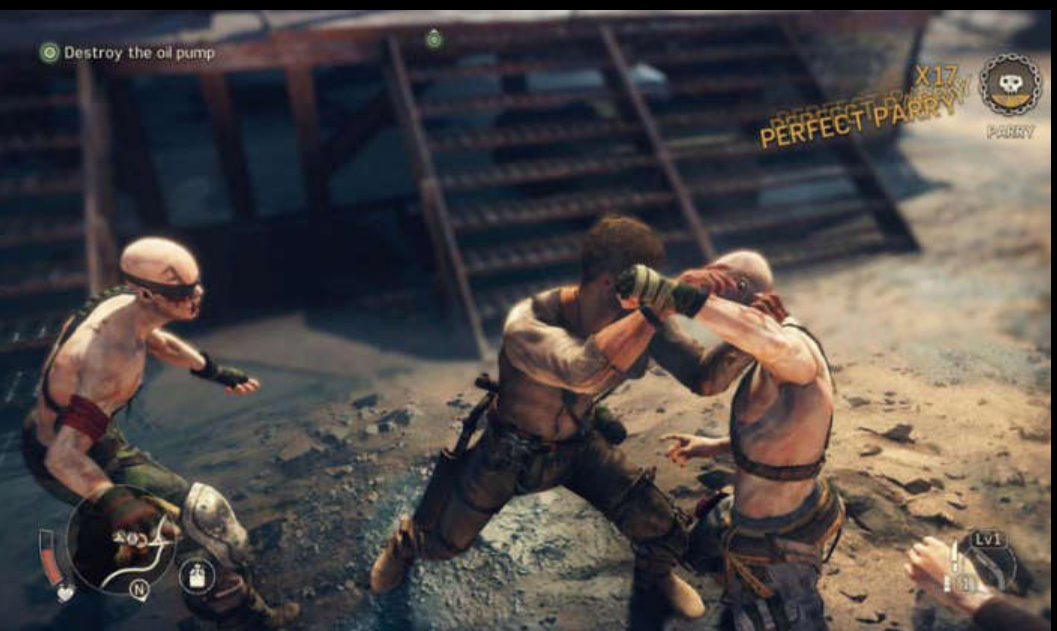
Destroy the oil pump
X17
PERFECT PARRY
PARRY
Lv1

Zombi / **£15** inc VAT

DEVELOPER Ubisoft Montpellier / **PUBLISHER** Ubisoft Montpellier / **WEBSITE** www.ubisoft.com/en-GB/game/zombi

Originally a Wii U launch title called ZombiU, Zombi sees you playing a survivor of an undead outbreak in London. After an introductory sequence that sees you chased into the London Underground, your character awakes in a safehouse created by an ex-soldier who calls himself the Prepper. The Prepper takes it upon himself to be your mentor, teaching you how to scavenge for supplies, battle the undead and stay alive, although he's completely fixated on survival. If you want any semblance of hope, you'll have to step out from under his protective yet controlling wing.

What makes Zombi immediately stand out from other games of its ilk is its eerie atmosphere. The game does an awful lot with very little; environments are flat and boxy, and you'll rarely see more than half a dozen zombies at once. However, each walking corpse you encounter can kill you with a single bite, while London's smoggy streets and shadow-stained underground prove adept at concealing them in unexpected places.

This haunted atmosphere also blends superbly with Zombi's most novel mechanic. When you die, that particular character is gone forever, and you respawn back at the safehouse as a different individual. What's more, your first task is to return to the previous survivor's corpse and scavenge what you can find from their backpack. If they became infected upon death, you'll have to fight them for it first.

This uncompromising approach to death makes Zombi's scares effective. Combined with limited resources that need to be carefully managed, and a gradually unfolding city map that must be carefully navigated, Zombi is a captivating example of virtual horror. Even the fairly basic combat is brilliantly balanced; guns are plentiful but ammo is scarce, while melee combat consists of a simple, desperate bludgeoning technique, which is handy when faced with one or two zombies but useless against more.

Sadly, not all of Zombi's ideas made it to the PC. On the Wii U, the inventory and map are on the controller's second screen, increasing the tension by forcing you to look away from the action when you needed to get your bearings or sort your equipment. On the PC, these features have been reworked into a more basic map/inventory system.

There are also no configurable graphics settings aside from resolution, and unorthodox default keyboard controls. The game bears a few bite marks too. The resource collection system, where you keep track of different city districts via CCTV to replenish supplies, isn't properly explored, and the game arbitrarily breaks some of its own rules toward the end, deactivating shortcuts through the city for no logical reason. But while Zombi may have lost a little vigour in its second life on the PC, overall it's still a triumph of its genre, with a thrilling sense of danger.

RICK LANE

OVERALL SCORE
80%

/ VERDICT
Smart, inventive and exceedingly creepy, Zombi is a survival thriller with teeth.

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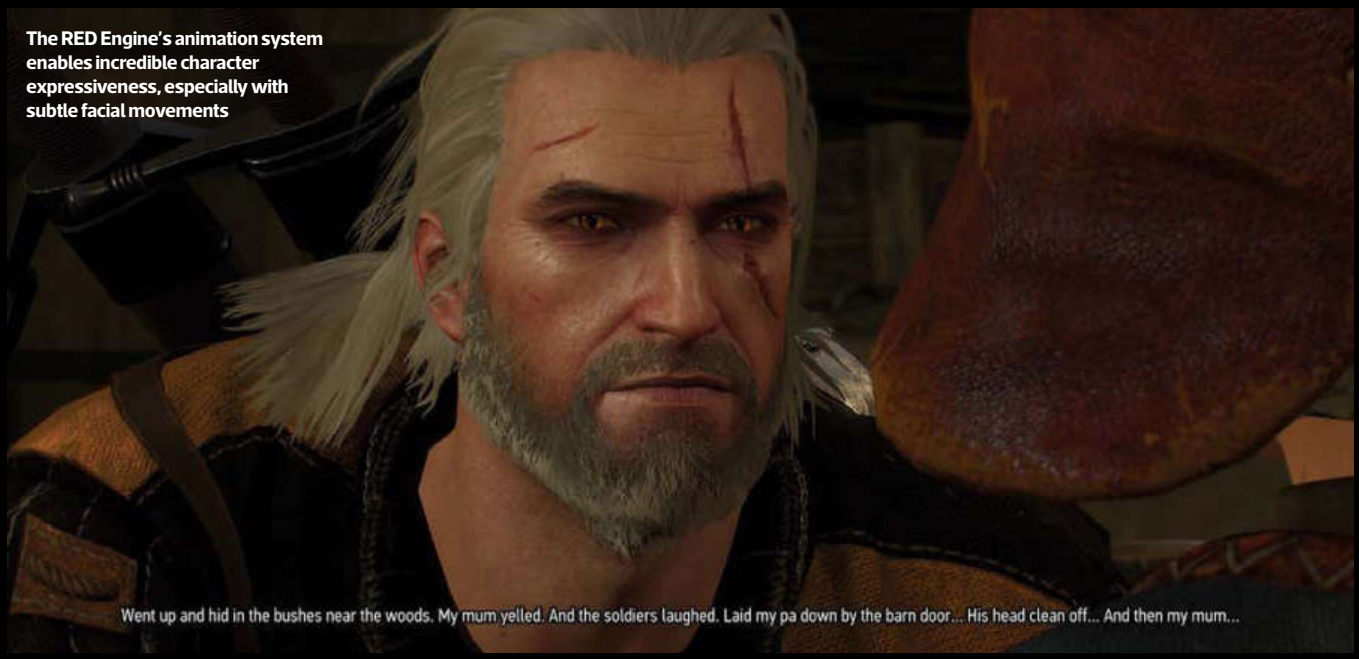


The RED Engine's animation system enables incredible character expressiveness, especially with subtle facial movements

RICK LANE / THE ENGINE ROOM

RED Engine 3

Rick Lane hunts down the technical secrets behind one of the best games of this year, The Witcher III: Wild Hunt

Despite being a mightily impressive RPG in its own right, The Witcher II was also a rescue project for its Polish developer CD Projekt. Prior to its creation, the company had burned through a huge amount of money attempting to create an Xbox 360 remake of the original Witcher game, named The Witcher: White Wolf.

This failure forced the team to curtail ambitions for a sequel, creating it in half the time it took to develop the original. Major cuts were made to the game's content, particularly to the final act, and the game's RED Engine, while undoubtedly beautiful, was poorly optimised at the time, resulting in fairly small environments.

For The Witcher III, CD Projekt wanted to avoid these compromises. It wanted a seamless open world, blending sprawling countryside with huge urban environments. It wanted realistic and consistent lighting, including a day and night cycle with beautiful sunrises and sunsets. It wanted emotive character animations to convey its morally ambiguous and deeply human stories.

The first priority was to better enable the RED Engine's formidable rendering power to represent the vast world CD Projekt wanted, which meant overhauling the engine's approach to level streaming.

Marcin Gollent, principal engineer programmer on the game, explains that the RED Engine originally streamed content through 'streaming areas', which were defined manually by artists. 'This is a simple and reliable solution, but requires some hand tuning, and when you're moving towards a 50km² map "some" hand tuning turns into "unbearable amounts" of hand tuning,' he says.

CD Projekt needed a more automated process that could determine when streaming was required without direct input from the developers. 'We ended up developing a very robust and complex system that automatically splits content both spatially, thus virtually implementing the concept of streaming areas, and logically,' Gollent says. 'The logical part happens during data baking, and some of the system's tasks are to organise the data into bundles and chunks, so that it best reflects the physical limitations of hard drives and Blu-ray discs.'

With an effective streaming system in place for large environments, the next challenge was filling those rolling hills and dense woodland with detail. The Witcher II set a remarkable standard when it came to rich fantasy environments. Matching that

standard manually over such a large area was an impossible task for CD Projekt's relatively small team, so automated solutions were once again required.

One of these automated systems 'is populating terrain surfaces with predefined sets of grass, rocks, stems or small bushes', Gollent says. 'It happens in runtime so we don't need to store spatial data, and it's easy to modify. This, coupled with double-layer terrain texturing and some offline vegetation generation, allows us to have decent-looking results without investing a lot of the artists' time.' With procedural generation acting as a sort of base clay, the artists then move in to sculpt and mould. 'They polish everything they see,' Gollent adds.

But The Witcher III's world isn't entirely rural. Its swamps and woodlands are pockmarked by small peasant communities, and parts of the landscape are dominated by large cities such as Novigrad and Oxenfurt. 'When thinking about the streaming system, we basically had two games to create: one game is Novigrad and the other is, well, all the rest,' Gollent says. 'Novigrad itself forced us to implement a set of features that are supposed to hide data-streaming delays.'

The Witcher III's world also possesses a very specific character, and conveying that mood in the environments was extremely important for the developers. To that end, RED Engine 3 employs fully dynamic lighting that adapts accordingly to time and weather conditions. 'It was also a must for us to seamlessly handle interiors without visible transitions or light bleeding,' Gollent emphasises, 'so we developed a solution based on localised environment probes and artist-controlled interior volumes, which allowed that.'

Alongside lighting, the aforementioned weather effects are vital to making The Witcher III feel alive. In particular, its simulation of wind is unique and remarkable effective. According to Gollent, the wind simulation is controlled by an overarching weather system that also determines other factors such as rainfall and cloud cover.

The game's dynamic lighting system has a 24-hour cycle, simulating moonlight as well as sunlight

'This consistent wind information is passed to multiple systems that control physical assets, hair simulation, 'dangle' simulation, foliage movement and so on. Each of those systems is left with a simple task: animate its subjects in the most convincing way possible,' Gollent says. For smaller objects such as foliage, this work can be handled by a vertex shader, which animates the individual vertices. But Gollent states that some objects need to be simulated physically, handing off the processing work to the CPU.

Of course, The Witcher games' focus has always been as much on characters as the game world, and much of the work involved in bringing the earthily charismatic population to life is done by the writing team. However, the RED Engine plays its part too, most notably in character animation.

'We improved the system in a few areas,' Gollent says. 'For example, we made it easier to move facial animation from one model to another, which improved iteration times. By investing more work in animation constraints, we improved eyelid behaviour and blinking. Also, a new animation-based 'look-at' system allowed us to make the characters behave more naturally when moving their attention from one interlocutor to another. For example, by tilting their head down and blinking.'

'Implementation of the golden hour effects (sunrise and sunset) was a long process, and proved that close collaboration between lighting artists and programmers is essential,' says Gollent

As well as their central role in the game's story, The Witcher III's inhabitants are also used as details in the world itself, thanks to a unique AI system within the RED Engine. In terms of individual AI, the game uses a fairly standard behaviour tree model, but the game also possesses a higher level of AI that acts almost like a hivemind to continuously populate the environments. 'We ended up developing a system that we called "Spawn Tree",' says Michał Słapa, principal AI programmer on The Witcher III. 'From the design point of view, it's quite similar to the way hierarchical AI systems are built. You can think of it as a kind of community AI that's meant to spawn and conduct high-level control over NPC groups.'

The end result of CD Projekt's work is plainly visible in the screenshots. Even more fascinating is the fact that the engine in the final game is scaled back from the initial concept demos shown in 2013. The rendering and lighting engines had to be altered because the team couldn't get the desired scale and draw distances using DirectX 11. However, with DirectX 12 bringing improved speed, we wouldn't be surprised to see another leap forwards when CD Projekt's next game, Cyberpunk 2077, arrives in two years. **CPC**

INDIE CORNER

Rick Lane takes a look at some of the forthcoming treats from independent game studios

Empyrion: Galactic Survival

DEVELOPER Eleon Game Studios / **RELEASE** Out now (Early Access)

With the recent resurgence of space games and the unceasing popularity of survival games, it was only a matter of time before someone combined the two and created Empyrion: Galactic Survival. The player begins Galactic Survival stranded on a hostile alien planet. Your ship is broken and your supplies limited. With only a handful of tools at your disposal, you must gather resources to repair your ship, and then head out in search of a friendlier planet for survival.

Galactic Survival has all you'd expect from both a space sim and a survival game: resource gathering, crafting, base building, ship flying, space combat – the works. However, it's how Galactic Survival blends these survival systems with its sci-fi theme that makes it interesting. Resources aren't merely limited to food, water and building materials – oxygen too has to be produced manually. Meanwhile, familiar survival staples such as campfires and hammers are replaced with generators and universal constructors.

Galactic Survival is enormously ambitious in scope, especially from a first-time developer, but these aspirations evidently have a cost. Visually, it looks pretty rough, and we don't know how the game will engender a sense of progression once you've safely escaped that initial planet. Even in its current Early Access state, though, there's already a huge amount to see and do.

Crest

DEVELOPER Eat, Create, Sleep / **RELEASE** Out now (Early Access)

There hasn't been a decent god sim since Black & White, and whenever one arrives that looks like it might be worth worshipping (From Dust, Godus), it turns out to be less divine intervention, and more smoke and mirrors. It's too early to say whether it will be worth constructing an idol to Crest, but it does arrive with more than a booming voice and a promise of paradise. Crest has *ideas*.

As with most god sims, Crest has you assume the role of an almighty sky-eye watching over an island populated by several tribes. You give these villagers commandments, but unlike other god sims, these commandments are deliberately ambiguous.

Crest's commandments comprise a verb and object that you select separately. For example, you might tell villagers to 'prioritise' 'young people'. However, it's up to your villagers to interpret this message. It could result in them having more children, or giving children more food, but your villagers will often get the wrong end of the stick, leading to mishaps and occasionally outright disasters.

It's an intriguing way of exploring the human phenomenon of searching for meaning in occurrences that are difficult to explain. Currently, though, Crest's AI needs considerable work, as many commandments seem to have no effect whatsoever. The final version is due for December.

Forest of Sleep

DEVELOPER Twisted Tree Games / **RELEASE** TBA

Forest of Sleep comes from the creator of cheerful walking simulator Proteus, which had dynamic music that changed according to environmental factors, and Forest of Sleep applies the dynamism of Proteus' soundtrack to storytelling.

Inspired by Russian fairytales, you guide a group of three boys along a path through a vast forest, helping out all manner of people along the way with various tasks. According to the developer, these events will happen procedurally. The game's unique story system ties together different elements on the fly, bringing characters in and out of the tale as it deems necessary, and leaving just enough of a gap in meaning for your imagination to fill, Dark Souls style.

One of the most intriguing aspects is the lack of dialogue. All character interactions are achieved through animation, with stances and expressions conveying tones and situations for you to interpret. You'll also need to keep an eye on the resource management system, although the developer says it exists to create interesting situations for the player, rather than being a necessary component for winning or losing the game.

Any attempt to blend the nuanced demands of storytelling with the random, unpredictable nature of games is worthy of admiration, and we'll be keeping a close eye on Forest of Sleep's development.

Outpost 13

DEVELOPER Cantina Games and Entertainment, Inc
RELEASE 27 October, 2015

Outpost 13 is an adventure game in which you basically play the 'Thing' from The Thing. It casts you as an alien life form named Tantalus who infiltrates a research outpost on the remote icy planet of Achelous. Your goal is simple – terrifying the crew members until they abandon their mission and evacuate the planet – taking you back to Earth with them. You achieve this goal by strategically killing off crew members while disguised as their lovable pet dog, Fen.

While Outpost 13 has the look of a traditional adventure game, there are dynamic elements at work. You need to distract and isolate crew members so you can kill them and remain undetected, using objects in the environment and the outpost's ventilation system to gain the upper hand. Raise the alarm, and the crew will come after you with flamethrowers – Outpost 13 isn't shy about its inspirations.

It's a delightfully twisted idea. The only question is whether the game's systems will let you be creative, or whether it will adopt a more conventional, puzzle-based approach. The fact that you can upgrade abilities for both Tantalus and Fen suggest the latter, so hopefully the game will possess the important dynamic core that the concept deserves.

Perception

DEVELOPER The Deep End Games / **RELEASE** 2016

At first glance, Perception looks like another Amnesia-inspired first-person horror game. You play a blind young woman named Cassie who has persistent nightmares about an abandoned mansion. After some research, she discovers her dream vision is a real place, and travels there to investigate.

Cassie can sense her surroundings with echolocation, so anything that makes a noise, such as a ticking clock or wind blowing through an open window, is revealed on screen in blue-tinted silhouette. Cassie can also reveal the environment around her by stamping on the ground. If she makes too much noise, though, she will attract the attention of The Presence, a supernatural inhabitant of the mansion.

Hence Perception becomes a terrifying balancing act as you try to navigate through the mansion undetected. The game also explores its notion of a blind protagonist in other interesting ways. Objects that you pick up are only revealed after rolling them around in your hand

for a while, and they could end up being useful, disgusting or disturbing. In addition, Cassie has a smartphone app with a video link to friends with sight, helping her decipher clues and puzzles.

Perception's success will rely on how the developer expands on this wonderful concept, and the strength of the connection between the game's audio and visual design. The early footage looks extremely promising though. CPC

Build a Radeon R9 Nano PC

Want to cram a whole Skylake system and a super-fast graphics card into a tiny case? Antony Leather enlists some help from Parvum Systems and AMD's new Radeon R9 Nano card to show you how it's done

With the release of AMD's Radeon R9 Nano (see p18), mini-ITX fans have never had it so good. The Nano currently represents the ultimate in terms of short-PCB gaming power, and while it can't quite handle every game at 4K, it comes tantalisingly close. You can, of course, spend more money and use a GTX 980 Ti, but it's a much larger graphics card, and you'll be left with less room for a tidy build.

This month, we've decided to take full advantage of the Nano by building a tiny PC that also sports an Intel Core i7-6700K, 16GB of RAM and a 512MB SSD – an awesome rig for gaming and much else besides. As if that wasn't enough, we've also worked with Parvum Systems to create a custom version of its X1.0 mini-ITX case, which can house an all-in-one liquid cooler, as well as providing great airflow to the graphics card.

ELITE NEW ENTRY P62

The components

THE CASE AND PSU

Parvum Systems X1.0 and SilverStone SST-SX600-G / £190 inc VAT

SUPPLIER www.overclockers.co.uk

While the Parvum Systems X1.0 mini-ITX chassis can house larger graphics cards than the Nano, the interior starts to get very cramped with a large card installed.

However, the R9 Nano fits perfectly in this case, allowing plenty of space for routing cables, and it doesn't look oversized for the case either.

The X1.0 also has space for a 120mm all-in-one liquid cooler, or a 120mm fan, at the front, while the roof section plays host to a large vent that allows the graphics card to breathe. There's a further 80mm fan mount at the rear of the case, but with such large vents elsewhere, a small 80mm fan isn't going to achieve much, so we've omitted it. A slightly different version of the X1.0 – the Veer – is available too, which has been altered to be more water cooling-friendly.

There's also space for two 2.5in SSDs, although there's no room for a 3.5in hard disk nor is there a way to mount a 5.25in device. The other potential imitation of the X1.0 is that it uses an SFX PSU, which limits your power options, but this decision has also enabled Parvum to drastically reduce the size of the case so that it measures just 250mm across and 310mm deep – it's truly tiny.

Besides, SilverStone makes excellent SFX PSUs. There's a wide range of wattages from which to choose, but given the power requirements of the R9 Nano, we opted for the 600W SST-SX600-G. It has more than enough connectors for our system, plus its 80mm fan is very quiet and shuts off entirely when the internal temperature is below 45°C – great if you're just web browsing or typing up an essay. What's more, **www.overclockers.co.uk** has a bundle deal at the moment for the X1.0 and SST-SX600-G for £190 inc VAT, saving you around £15.

THE GRAPHICS CARD

AMD Radeon R9 Nano / £500 inc VAT

SUPPLIER www.overclockers.co.uk

If you want the smallest graphics card possible, but don't want to sacrifice performance then AMD's R9 Nano is currently your best option. At barely 152mm long, its PCB is a whole 20mm shorter than Asus' already tiny GTX 970 DirectCU Mini, or any other short-PCB GTX 970 for that matter, which is your only other short-PCB option, unless you have room for the Fury X's separate liquid-cooler.

In fact, the Nano is so small that it even appears lost in our tiny X1.0 case.

Performance-wise, the Nano is close can play some games at 4K, but it's borderline. Crysis 3 saw the minimum frame rate drop to 24fps, which would only require a little tweaking to make it playable. Meanwhile, its 28fps minimum in The Witcher III: Wild Hunt is playable, but it's also close to the line.

You'll have to drop a few of the settings in some games to get smooth frame rates at 4K, but the good news is that games at lower resolutions, such as 3,440 x 1,440 or 2,560 x 1,440, will be perfectly playable.

THE COOLER

Corsair H80i GT / £80 inc VAT

SUPPLIER www.scan.co.uk

The X1.0 only has space for a 120mm radiator so, to maximise the cooling on offer, we've opted for the Corsair's H80i GT. It has a thicker radiator than the smaller, cheaper H75which enabled it to knock a few more degrees off the CPU load temperature in our testing. As it's more important to get the heat out of a case than

Going custom with Parvum systems

It isn't often that a case manufacturer is able to completely customise your case, but we're lucky enough to have Parvum Systems in the UK, and if you've seen some of the Parvum-based PCs on the Internet, you'll know how many colours and designs are available already. During our visit to the factory last year, Parvum Systems highlighted its ability to offer customisation services for its cases.

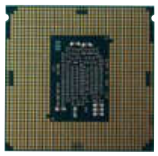
As well as adding logos, the team can also cut out additional or repositioned fan mounts, giving your case a unique design, or one that's better suited to your cooling hardware than the default design. The team can even create highly accurate renders so you can see how your case will look before you go ahead. For example, we went through a few colour changes before settling on our red and silver theme.

to push cool air into it, we'll be installing it as an exhaust. It also has an excellent software suite, and there's enough space in the X1.0 to mount both its fans too.

THE CPU

Intel Core i7-6700K / £319 inc VAT

SUPPLIER www.scan.co.uk



If you're aiming to pack some serious grunt in the CPU department, then your best option for a mini-ITX system is the Core i7-6700K. ASRock does have a mini-ITX X99 board, but your cooling options are limited and the system cost will be substantially higher.

However, the Core i7-6700K is very overclockable and can also process eight threads simultaneously, thanks to its four CPU with Hyper-Threading support.

THE MEMORY

16GB (2 x 8GB) Corsair Vengeance LPX 2666MHz / £90 inc VAT

SUPPLIER www.scan.co.uk

As you'll need to buy new DDR4 memory for this system, rather than using older DDR3 RAM you may have spare, we've decided to add 16GB of Corsair's low-profile Vengeance LPX RAM to give our system a bit of future proofing. Remember that mini-ITX motherboards only have two DIMM slots, so you won't be able to add another couple of sticks in the future, which is another reason to opt for 16GB rather than 8GB now.

THE MOTHERBOARD

Asus Z170i Pro Gaming / £130 inc VAT

SUPPLIER www.cclonline.com

There are very few Z170 mini-ITX motherboards around at the moment, but Asus' Z170i Pro Gaming turned out to be a fanta board when we reviewed it this month (see p26), so it's currently our firm choice for a mini-ITX Z170 motherboard.

What's more, it also sports an M.2 slot long enough to support some of Samsung's super-fast SSDs, such as the SM951 or newly released 950 Pro.

STORAGE

Crucial BX100 500GB / £135 inc VAT

SUPPLIER www.ebuyer.com

If you're going small, then the first sacrifice is usually space for hard disks. However, the vast majority of us only need a single hard disk and SSD anyway, and you don't even need the former if you have a NAS box at home. As such, the X1.0 has ditched the 3.5in form factor entirely and opted for two 2.5in mounts instead.

We'll just be using a single 500GB Crucial BX100 SSD in this build, which still offers plenty of space for Windows, numerous games and applications, while still leaving hundreds of gigabytes of solid state storage for data.

Total hardware cost: £1,444 INC VAT

The build

One of the joys of a Parvum case is that you get the pleasure of building it yourself. Don't worry if you have a phobia of flat-pack furniture though – the X1.0 is simple to build and just requires you to build it around the hardware, rather than installing it all in one go.

Start by laying out all the parts to familiarise yourself with the panels and components. The X1.0 doesn't include any instructions – instead, you'll need to take a look at the Parvum Systems X1.0 assembly video on YouTube. 01

The case is held together using corner supports and screws, so your first step is to mount these supports to the base of the case, following the video. The side panels, motherboard tray and both end sections affix to this area. 02

You can now attach the motherboard tray. Remember to use the correct length of screws as well – 6mm and 10mm screws are supplied, with a small selection of large-threaded 10mm screws for the PSU. The video also clearly shows the correct orientation for the base – pay close attention to this part, as it's easy to install the base and other components the wrong way around. 03

The Corsair H80i GT has two 120mm fans, but the X1.0 also sports a fancy-looking 120mm fan. We decided to use the latter as the radiator's intake so that it's on show through the side window. Don't install the second rear fan just yet though. 04

You'll need to mount the radiator or front fan before you install the front panel. 05 The screws pass through the second panel – in this case, silver – and the red section then sits on top. As a result, the fan screws are hidden. Pass the screws through the panel and rear fan, then secure the radiator to the case. 06

You can now secure the front panel, adding the three corner supports at the top, followed by their opposite numbers at the other end of the case. 07

The two supports closest to each other can then provide a mount for the SSD storage tray, which sits at the top of the case, behind the motherboard and above the PSU. 08

There are no USB ports to mount, but you need to wire up the power button. There are four cables – two apiece for the power button and power LED, which connect to the corresponding headers on your motherboard's front panel connectors. You can connect the coloured wires as shown – the inner two wires are for the power button and the outer two wires are for the power LED. 09

Thread the cable through the case power button hole, then use the locking ring to secure it to the case. It's an anti-vandal switch so you can replace it with quite a few different types and colours. 10

Your next job is to fit the Corsair H80i GT's backplate to the back of the motherboard. On LGA1151 sockets, this backplate is a single-piece affair, with four pins required on the top side. 11 You can now test-fit the motherboard with the RAM installed, to make sure it all fits in place. 12

There's plenty of room for Corsair's relatively low-profile LPX DDR4 modules with our setup, so install them and the CPU into the motherboard. 13 You can then insert the motherboard's I/O blanking plate at the rear and install the motherboard. We found that mounting the cooler's pump section with the logo the right way up allowed the tubing to bend round in the least forceful way, while also leaving some clearance from the side panel. 14

With a single SSD and one power cable going to the GPU, there aren't many power cables, but it's still important to tidy all the wires together to improve airflow. We've used Cable Modders Cradle Mount cable anchors, which you can pick up from www.watercoolinguk.co.uk for £2.75 inc for a pack of 20, and they work perfectly within the X1.0's tight confines. 15

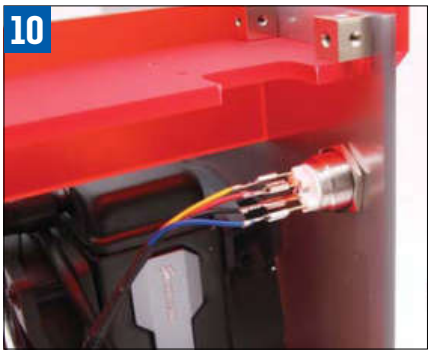
SSDs are mounted using the smaller 6mm screws, which simply pass through the mounting panel and screw it in place. From here, the SSD is within easy reach of the motherboard through routing holes in the motherboard tray. 16

The PSU sits on its side, and the X1.0 has a side vent for its fan, so make sure you point the PSU fan at the side. Parvum includes screws for the PSU, which have a thicker thread than the fine ones used with the corner supports. 17

The graphics card is the last piece of hardware to be installed, and again the case is built around it, as the outer rear panel locks it in place. With this panel removed, install the graphics card then connect the 8-pin power cable. 18 19

Now install the outer rear panel over the inside one. As you move it into position, it will hold the graphics card in place, so there's no need for any further screws. You might need to use a little force to get the screwholes to line up, though, and make sure the graphics card is still properly slotted into the motherboard too. 20

The SST-SX600-G PSU is fully modular, which makes installing it easy, but more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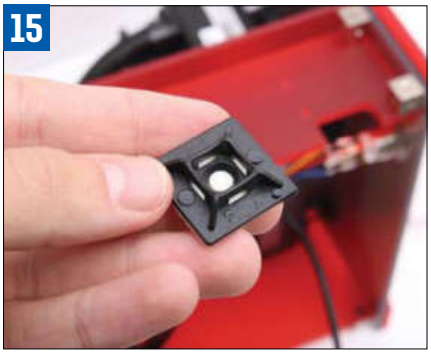
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importantly, means you can remove any cables you don't need. For example, we have no need for the 4-pin Molex connector cable, so remove any cables you don't need to reduce the number of cables you have to tidy. 21

With all the cables attached and routed, use a couple more anchors to tie up the rest of the cables. As they're all located in the rear section with the PSU and SSD, there's no airflow to worry about, but it still looks much neater if you at least gather them all together. 22

The side panel and window are made from two separate sections and are held together once you've mounted them to the rest of the case. 23

Pass the screws through the four corners, then give the interior a once-over to make sure you haven't missed anything – removing the side panel isn't as easy as with a traditional PC case. You can then secure the panel and window to the case's exposed corner supports. 24

The roof will be the final part of the case to be installed, and it just needs to be screwed into the corner supports. Make sure you align the vent in the roof so it that sits over the graphics card's fan. 25

With the system complete, make sure there are no screws missing, and then tighten them up. Not doing so can lead to vibration or a lack of rigidity, which you definitely don't want if you'll be transporting your machine to LAN parties. 26 CPC

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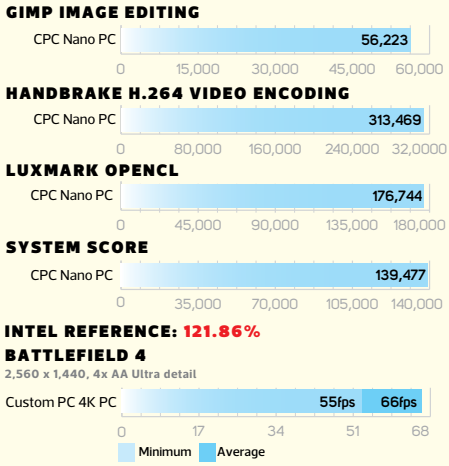
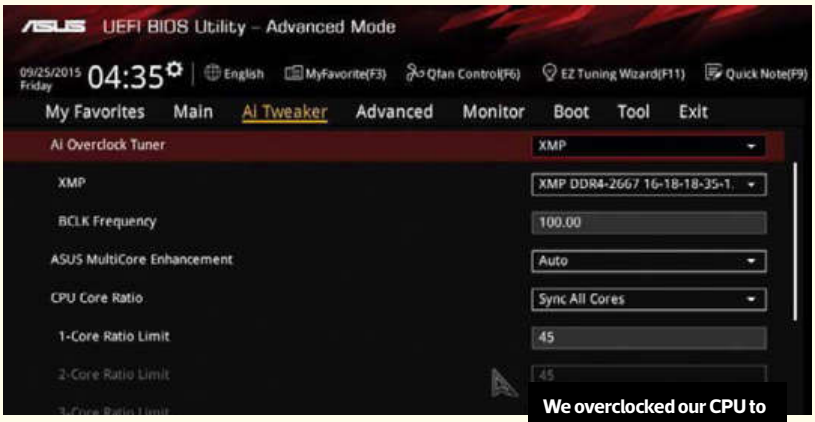
Performance and overclocking

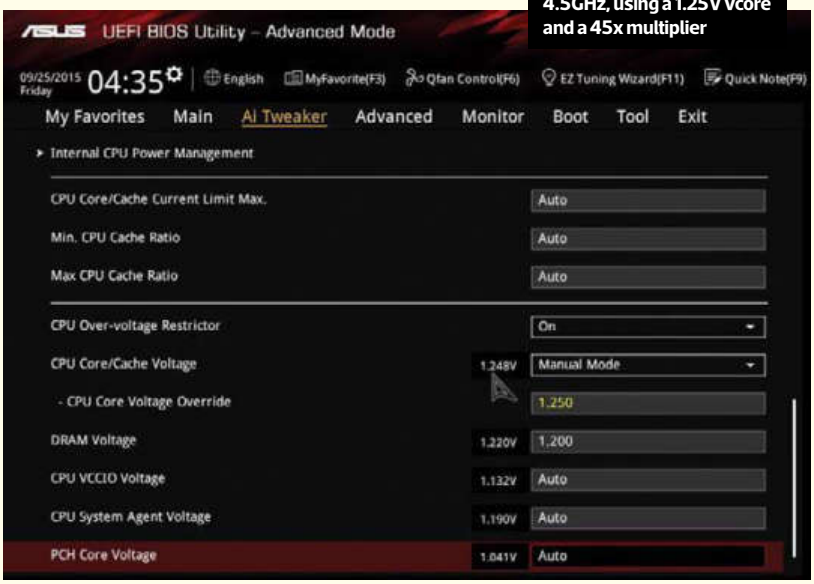
To give our system a free boost, we overclocked the CPU to 4.5GHz, using a vcore of 1.25V and simply raising the multiplier to 45x. You can stress-test your overclock to make sure it's stable by using the smallfft test in Prime95 (use version 27.7 or lower, as later versions can cook Haswell and Skylake CPUs), and if you're feeling adventurous, you may be able to push your CPU further. You can't overclock the R9 Nano's memory, but we increased the GPU core frequency from 1000MHz to 1070MHz using MSI Afterburner, while also increasing the power limit by 50 per cent.

These tweaks saw the minimum frame rate in Battlefield 4, go from 50fps to 55fps, at 2,560 x 1,440 with 4x AA and Ultra detail. Meanwhile, the extra CPU grunt saw the overall RealBench 2015 system score rise from 132,454 to 139,477. The peak power draw was also just 332W with both overclocks applied, which is easily within the limits of our PSU. In terms of temperatures, the GPU sat at a modest 70°C and the CPU peaked at 76°C – with an ambient temperature of 23°C, the delta Ts were 47°C and 53°C respectively.



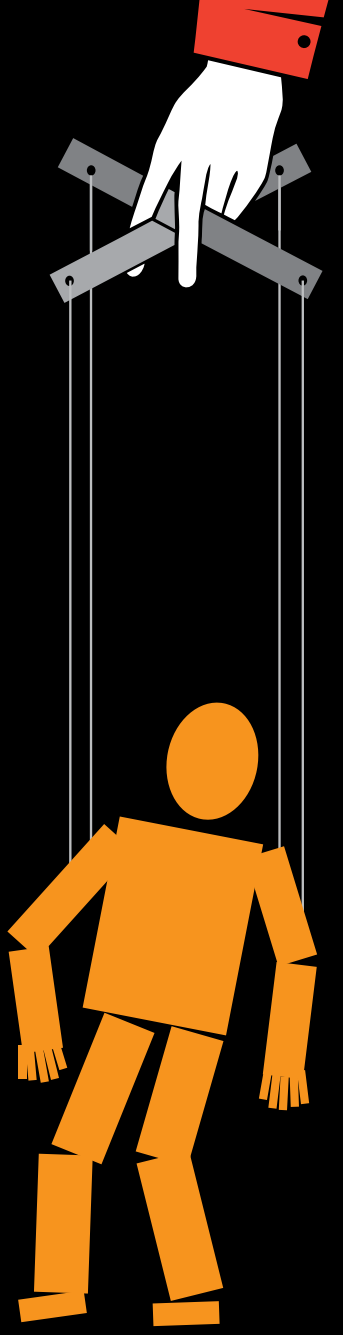


We overclocked our CPU to 4.5GHz, using a 1.25V vcore and a 45x multiplier



PUPPET MASTERS

THE INVISIBLE WORLD OF VIDEO GAME AI



IT'S COMMONLY BELIEVED THAT VIDEO GAME AI HAS BARELY IMPROVED SINCE THE 1990s, BUT IS THIS TRUE? RICK LANE INVESTIGATES

The years between 1997 and 2001 are often considered a golden age of video game AI, encompassing a spate of fascinating games that appeared to make giant leaps forwards in how players could interact with non-player agents and vice versa.

The touchstones are all fondly remembered. Stealth games such as Thief introduced behaviour states that went beyond the straightforward, binary choice of passive or aggressive, which was previously the norm. Social simulations such as Dungeon Keeper and The Sims brought us NPCs with simulated emotions who interacted with each other and affected one another's behaviour. Most famously of all, Lionhead's Black & White AI could apparently learn new skills and employ them in ways that reflected a particular personality.

This cluster of games so rapidly expanded our understanding of the capabilities of game AI that it seemed as though the future games would be AI-driven, but that wasn't the case. Aside from a couple of games, such as Monolith's F.E.A.R, and Paradox's Crusader Kings series, game AI has appears to still be relying on the basic principles established in the late 1990s and early 2000s. Is this really what's happened?

'No,' says Hugo Desmeules, lead AI designer on Ubisoft's Far Cry series. 'I remember the games we were making in 1999, when we were programming enemies with simple brains and patterns. The technology at that time didn't allow us the freedom we have now, which translates into sampling the environment with heavy physics simulation, tonnes of math processing and a great deal of objects in memory.

AI IN AN OPEN WORLD

'Today you can have a gigantic navigable world in a game such as Far Cry 3, with a full day/night cycle, a whole bunch of enemies and vehicles at the same time, fire simulation, real physics and a lot of persistency. Those ingredients, when gathered together, have pushed the process of building AI brains to a whole new level.'

The Far Cry series provides an interesting case study in terms of how computer game AI has and hasn't evolved. From Far Cry 2 onwards, the player explores vast open worlds pockmarked by enemy encampments. A major part of the game involves liberating those encampments from the AI's grasp through a combination of stealth and gunplay.

On a fundamental level, the AI techniques that Ubisoft employs are little different from those seen in Thief. 'The AI brain has three main states – idle, alert and combat,' says Desmeules. These behaviour states, known in AI development as finite state machines, are essentially identical to those first explored in Thief. Enemies

The Sims brought us NPCs with simulated emotions who interacted with each other and affected one another's behaviour

stick to set patrols while idle, switch to searching for the player when alerted and attack the player when in combat.

At the same time, the number of eventualities the AI needs to accommodate has expanded enormously. To start, the game world is now open, with both players and AI characters able to wander in almost any direction. While Thief's AI characters had to navigate through fairly restricted environments of rooms and corridors, Far Cry's AI pathfinding must account for hills, rocks, trees, rivers, vehicles, buildings, interiors – the list goes on.

And it isn't simply navigation that's more complicated. 'There are so many emergent situations that the NPC brain needs to be a lot more complex,' Desmeules says. 'Simply take the example of an AI [character] completely surrounded by fire near a river. A simple evolution towards smarter AI would be to teach them how to swim. In a more linear game, you would probably be able to prevent this situation by not allowing the player to have a flamethrower, but in an open-world game such as Far Cry 3, the player can do pretty much anything they want.'

Indeed, the demands of both the player and the environment on the AI are so great that it's tremendously difficult to take all the different potential scenarios into account. 'The way we structure the AI code is crucial and can't be a sum of special cases everywhere, so the hardest part is to keep a simple code/data model where it's easy to scale the AI brain.' says Desmeules. 'To know we've done it right, we can test it by adding a feature such as swimming with the desired complexity, then creating a new animation, recording new dialogues, new particle effects and so on.

'The brain part [of the AI] should already be generic enough to support navigation from A to B, and react to bullet hits and state transitions. Only the data used during this action should be different. Maintaining this philosophy isn't easy and it's a daily battle.' Yet despite the fact that Far Cry 3's AI characters can swim, drive vehicles and call in support from other bases, alongside many other abilities, from the player's perspective, they don't *seem* much more intelligent than the guards in Thief.

THE NUMBER OF EVENTUALITIES THAT THE AI NOW NEEDS TO ACCOMMODATE HAS EXPANDED ENORMOUSLY

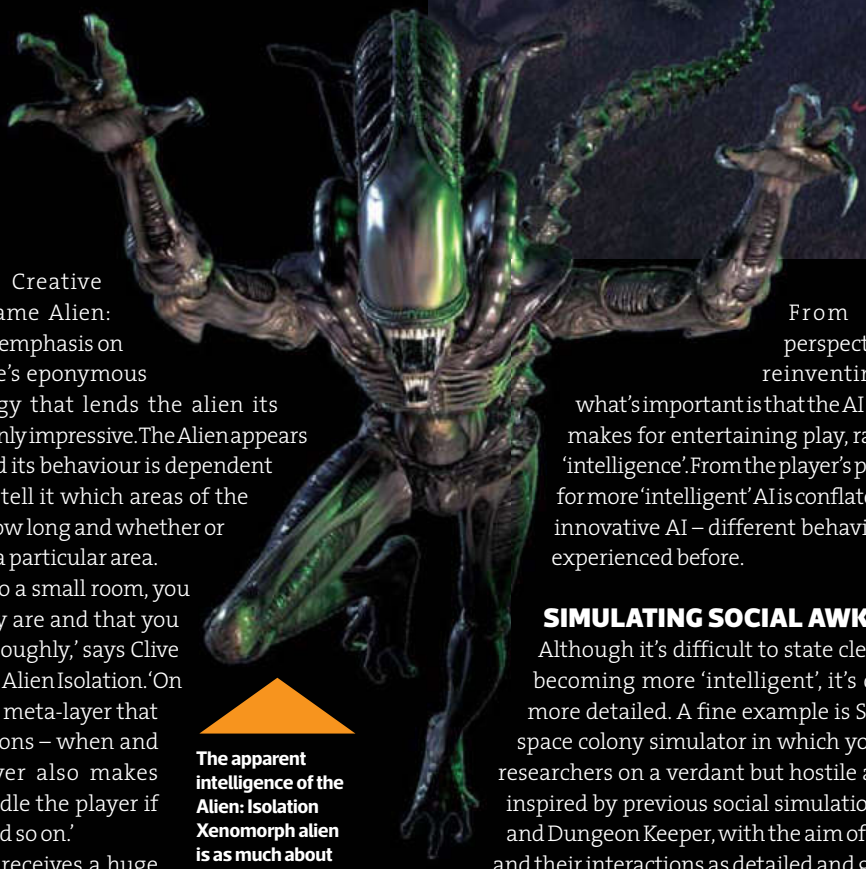
The reason is that AI development in video games is a knotty subject that depends upon a huge variety of factors. To start, the significance of AI development in a game depends on the type of game you want to make and whether there are AI techniques that cater towards that type of game. There are many well-established

Far Cry 4's AI is based on tried and tested methods, but with far more complexity

game genres now, and most have tried and tested ways of implementing AI that suits them. For example, when Thief launched, the 'alert' state crucial to making a stealth game work didn't exist.

This innovation was part of what led to Thief being viewed as such a groundbreaking game. Far Cry requires this state to function too, but it doesn't need to invent it. Plus, although it adds dozens of smaller details on top of this framework, we don't notice the improvement because they're subtler iterations on an existing idea.

For players, perceiving these subtle improvements is far harder than in other areas of game development such as graphics or animation, where every change is directly visible on the screen. As such, we only pay attention to a game's AI when it deliberately draws our attention to it.



The apparent intelligence of the Alien: Isolation Xenomorph alien is as much about artistry and level design as it is about AI programming

INSIDE THE XENOMORPH BRAIN

A recent example is the Creative Assembly's sci-fi horror game Alien: Isolation, which places great emphasis on the intelligence of the game's eponymous Xenomorph. The technology that lends the alien its apparent intelligence is certainly impressive. The Alien appears in the game dynamically, and its behaviour is dependent on various parameters that tell it which areas of the environment to search, for how long and whether or not it 'knows' the player is in a particular area.

'If you follow someone into a small room, you have a good idea where they are and that you should search the room thoroughly,' says Clive Gratton, technical director on Alien Isolation. 'On top of this AI, we also have a meta-layer that makes more strategic decisions – when and where to appear. This layer also makes decisions about how to handle the player if they have a flamethrower and so on.'

In other words, the Alien receives a huge amount of support from the game itself in making it appear intelligent. The game's excellent modelling, animation and sound design lend the Alien a terrifying presence when it's in the same room as you, and the levels are constructed from small rooms and corridors to minimise glitches or pathfinding problems. Finally, Sevastopol Station's ventilation system enables the Alien to seamlessly traverse environments, popping in and out of the game world without breaking the immersion.

Whereas Far Cry uses its AI to facilitate a specific idea, Alien: Isolation builds its game entirely around its AI, and that's what makes its Xenomorph such a powerful portrayal of predatory cunning. The alien appears intelligent because the developers work hard to convince you of this fact through every aspect of the game, while minimising the number of factors that the Alien itself needs to think about.

This is why it's difficult for gamers to gauge the extent of AI's progression. From the developer's perspective, there's no point reinventing the wheel, and what's important is that the AI feels convincing and makes for entertaining play, rather than its actual 'intelligence'. From the player's perspective, the desire for more 'intelligent' AI is conflated with the desire for innovative AI – different behaviour that we haven't experienced before.

THE ALIEN APPEARS INTELLIGENT BECAUSE THE DEVELOPERS WORK HARD TO CONVINCE YOU OF THIS FACT

SIMULATING SOCIAL AWKWARDNESS

Although it's difficult to state clearly that game AI is becoming more 'intelligent', it's certainly becoming more detailed. A fine example is Simon Roth's Maia, a space colony simulator in which you oversee a team of researchers on a verdant but hostile alien planet. Maia is inspired by previous social simulations such as The Sims and Dungeon Keeper, with the aim of making its colonists and their interactions as detailed and granular as possible.

'To start, every colonist has over 50 base desires, ranging from those attached to bodily functions, hunger, thirst, fatigue and so on, to higher-level emotional wants such as social contact and a wish to express themselves,' says Roth. 'They also build their own model of the base's requirements, safety, security, food production and so on, so they can plan workloads in an efficient manner.'

According to Roth, objects in the game world then 'advertise' their ability to satisfy specific needs. Any colonist or creature that interacts with an object will retain some knowledge of its effectiveness, which influences their likelihood of using it in the future. 'This system also lets objects misleadingly advertise their usefulness, allowing for items such as animal traps, which offer food but don't provide it,' he adds.

Alongside needs, colonists also have emotions and moods that affect (and are affected by) the satisfaction of needs and interactions with other colonists. 'Currently, the colonists have basic social interactions where they can

In Maia, colonists' behaviour changes according to their mental state

A nav mesh of a machine-learning bot in Unreal Tournament 2004

wave to, talk to, hug, threaten or assault each other. This fulfils their desire for social interaction (attention), but also feeds back directly into their emotional simulation. Their moods rub off on each other, so an irritated colonist may end up making your whole base annoyed or upset as the interchanges go sour.'

One of the most important aspects of Maia is that every AI agent is individually simulated. There is no 'higher-level' AI that connects or oversees them. As Roth puts it, the colonists can't read each other's minds. Roth gives the example of two colonists who need to use a specific item, but don't know about the other colonist's need to use it. 'If they arrive at an item already in use, they can choose to wait in the room if they can withstand the social awkwardness, but they may instead decide to use a different object to save themselves the embarrassment.'

This level of detail in individual, autonomous agents simply wouldn't have been possible 15 years ago – the demand on the CPU would have been intolerable. However, Roth says the bigger problem is conveying the thoughts and emotions of colonists effectively to the player. 'In recent builds, we've been adding a lot of hammed-up animations, expressing a wide range of mixed emotions, but often the cause of a mood isn't as clear as it needs to be,' he says. Again, our understanding of what makes a good game AI system is as much about our perception of it as players, as it is about the algorithms developers write in their code.

MACHINE LEARNING

The notion that AI ceased to progress around the year 2000 is a myth. That said, there's one area of AI where games have stagnated – machine learning, where AI is capable of learning new skills and then applying them autonomously in a given environment. In the entirety of gaming history, only a handful of games have dipped their toes into machine learning – the most famous being Black & White. Not surprisingly, Black & White is frequently touted as the best AI-driven game of all time.

Since Black & White, the game industry has barely touched machine learning. Most of its applications are consigned to academic circles. The most notable time the two have crossed over recently was in 2012, when a team from the University of Texas won that year's Unreal Tournament 'Botprize', with a bot so lifelike that testers were unable to tell whether it was human or not.

The team was put together by AI researcher Risto Miikkulainen. The team tracked data on how human players navigated UT's maps, and the bots were taught to apply those navigation techniques independently via a technique called 'evolutionary computation'.

'The idea was that first we would try to evolve the best possible combat behaviour,' says Miikkulainen, 'We'll have a bunch of bots in the level, play with and against them, and the best versions of the bots, the best neural networks, will survive and be passed on.' Unfortunately, this method resulted in bots with superhuman skills, so the team had to find a way to rein them in. 'We added a bunch of constraints that we thought were human-like constraints, and then optimisation under those constraints resulted in behaviour that actually looked very human-like,' Miikkulainen explains.

What's interesting about this project isn't so much the result of the team's work – bots which passed the Turing test within the context of the game – but the process through which they got there. It hints at how machine learning could be adopted into mainstream gaming. Imagine a Pokémon game where you trained the creatures yourself, or a football management game where you coached AI players in tactics.

Miikkulainen even explored this idea in 2005 by developing a game called NERO, wherein players train special-ops soldiers for combat deployments.

'The behaviour that comes out of these techniques is much more complex, and it can be more interesting – just the fact that you would have agents that adapt and change their behaviour is hugely interesting, and it can create entirely new games.'

Ultimately, the game industry is driven by ideas, rather than any specific technology or presiding artistic theory, and within gaming at least, AI is a technology – a tool rather than a goal. But that doesn't mean the industry has given up on AI at all. Indeed, as hardware becomes increasingly powerful, it opens up new opportunities that AI programmers are already keen to explore.

'We would love to see hardware that allows database storing of facts to help the AI make more complex decisions,' says Desmeules. 'This would require more memory space and processing power, so yes, hardware could definitely improve AI complexity.' CPC

GARETH HALFACREE'S

Hobby tech

The latest tips, tricks and news in the world of computer hobbyism, from Raspberry Pi, Arduino and Android to retro computing

REVIEW

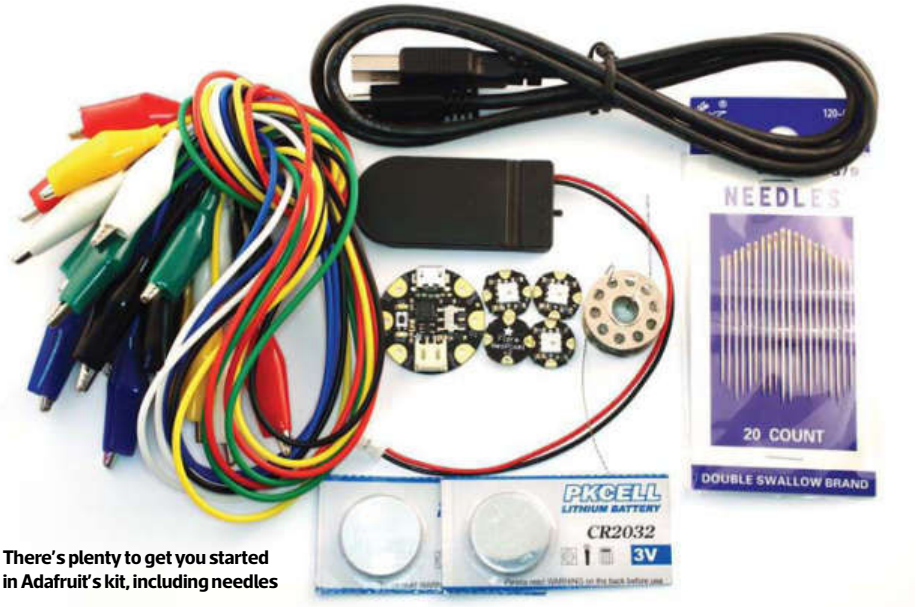
E-textile kits

Hands on with Adafruit's Gemma Starter Kit and Kitronik's Electro-Fashion Deluxe E-Textiles Pack

The world of wearables can, at first glance, seem unwelcoming to the hobbyist. While making device similar to an Apple or Pebble smartwatch is perhaps a little overenthusiastic for a first project, there's an easy way to get started with a simpler project: conductive thread. In a traditional circuit, electricity is carried via copper wires or traces on a circuitboard. Conductive thread is designed to replace this material: it carries electricity just like wiring, although less efficiently, but can be used almost exactly like cotton thread – it can even be placed into a sewing machine.

A spool of conductive thread on its own isn't enough, though, and that's where a pair of starter kits from noted maker-suppliers Adafruit and Kitronik come in. The two kits share plenty of similarities. They're both designed for people with little to no experience of what's becoming known as e-textile or soft-circuit creation, and they both focus heavily on the simplest of projects: making LEDs light up.

The Kitronik kit forms an introduction to what the company calls its Electro-Fashion range. The surprisingly small packet, enclosed in a blister pack, contains almost everything you need; there's 6m of Kitronik's own conductive thread, created by plating traditional thread with silver, three battery holders with matching batteries, three colours of sewable surface-mount LEDs (two LEDs for each colour) cleverly placed on tiny circuitboards, three more colours of full-sized LEDs (two LEDs for each colour) with built-in flasher circuits, a slide switch, and a momentary push switch.



There's plenty to get you started in Adafruit's kit, including needles

I say 'almost' everything you need, because there's definitely a missing component: a pack of needles with which to sew. The Adafruit kit, by contrast, includes a pack of needles of varying sizes, 25m of two-ply conductive thread made purely from stainless

You need to make sure you don't short the circuit by crossing over your previous seams

steel and handily loaded onto a machine-compatible bobbin, four 'Flora' RGB LEDs, a battery pack with a JST connector and two batteries, a set of very useful coloured crocodile leads for testing circuits before sewing components down, and the star of the show – the Arduino-compatible Gemma wearable microcontroller, complete with micro-USB cable for programming.

Regardless of which pack you choose, the process for building a circuit is the same – handily detailed in a colour guidebook included with Kitronik's kit, while the paperwork-free Adafruit version requires you to go online to learn how to use it. You then just need to thread the needle, although neither kit saw fit to include a needle threader, which would have been particularly welcome when using Kitronik's soft but thick conductive thread, and start sewing components onto your chosen material.

To practise, I began sewing LEDs into the fingertips of an old glove. If you've ever done any sewing before, using conductive thread is no different from normal thread, except you need to make sure you don't short the circuit by crossing over your previous seams. The large, through-hole LEDs in the Kitronik kit require their legs to be bent into eyelets, a procedure detailed in the manual, while all the other components from both kits sew directly onto your material.

When you've finished adding blinking or plain LEDs to material, you'll have outgrown the Kitronik kit and will need to pick up some more components from the Electro-Fashion range – or any e-textiles range, really – but the Adafruit kit keeps going. The Gemma is a fully functional, sewable microcontroller, programmed directly from the Arduino IDE, and giving the kit plenty of room to grow.

There are, naturally, caveats. A move to the compact ATtiny reduces the capabilities of the Gemma considerably compared with ATmega Arduino compatibles; there are only three GPIO pins, although two of them offer PWM control for LED dimming and the third can be switched to act as an analogue input for sensors.

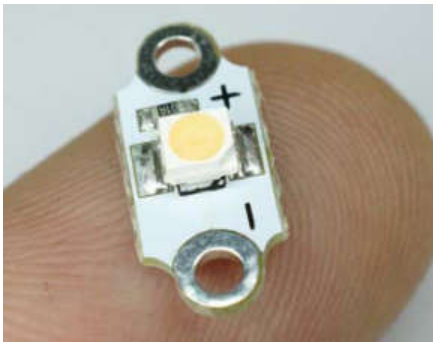
The serial port is also tied up dealing with the USB connection, which means there's no option to add Bluetooth or Wi-Fi. The Gemma also uses 3.3V logic, as opposed to the 5V logic of most Arduino models.

That's all being picky though. If you're an Arduino enthusiast, the Gemma – built in collaboration with Arduino.cc – is a great way to begin experimenting with wearable projects, and requires no esoteric knowledge. It's also far more flexible than the basic components supplied with the Kitronik kit, although it's naturally a little more expensive as a result.

Comparing the two, though, the Adafruit kit has the edge for me, although neither kit is perfect. The bundled instruction pamphlet of the Kitronik kit means it's a quick starter, but only if you already have sewing needles to hand. Meanwhile, the Gemma is extremely flexible, but would it really have broken the bank for Adafruit to include some printed documentation with the bundle?

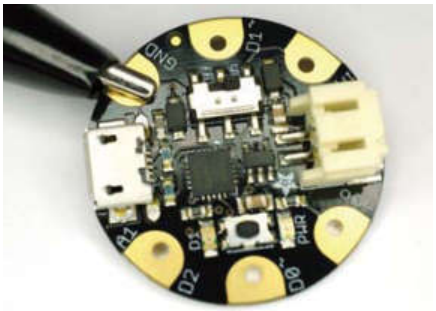
Both kits are available now from **http://cpc.farnell.com**, priced at £23.33 inc VAT for the Gemma Starter Kit (code MK00260) and £14.92 inc VAT for the Electro-Fashion Deluxe E-Textiles Pack (code MK00100).

Kitronik's Electro-Fashion kit isn't as feature-packed as Adafruit's kit, and there isn't a needle in sight



If you're hoping to use these kits with children, be aware that some of the included components are extremely small

Thickness aside, there's little difference between the process of sewing normal cotton thread and conductive thread



The clips included in the Gemma kit make it easy to test your circuits before sewing

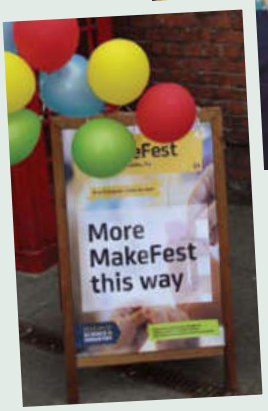
It's easier to work with the thinner, all-metal Adafruit thread than Kitronik's thread

EVENT
Manchester MakeFest

Before talking about Manchester's first MakeFest, held at the wonderful Museum of Science and Industry (MOSI), there's a clarification that must be made: the Manchester MakeFest is in no way, bar perhaps thematically, related to the Liverpool MakeFest from Issue 145.

'It was a bit of a happy coincidence really. We just both come up with MakeFest as a name,' explains Susannah Williams, MOSI's contemporary science event manager and one of the event's organisers, although it was operating under the similar banner of Manchester MakerFest until surprisingly late in the event's promotion. 'We have a lot of makers who have been to Liverpool MakeFest as well, you know; they all go around the same sort of circuit. It's been quite nice to have that, especially as we're on the site of the original Liverpool-to-Manchester railway, so we used to send people to Liverpool and we've got that little connection now with the two MakeFests!'

Rachael Moat's musical bowls, driven by a Bare Conductive board, were a smash with kids



There's certainly overlap between the two events. As I walk around, I see familiar faces from York and Leeds Hackspaces, as well as DoES Liverpool's Nerf shooting gallery. Even for those who attended Liverpool MakeFest, though, there's plenty new to see, including a great show from the Manchester Vintage and Retro Computing Enthusiasts group, which is demonstrating how to program the Manchester Baby, the first stored-program computer and an exhibit at the museum, while a clattering teletype machine prints ASCII art samples from paper-tape input.

MakeFest isn't the Museum's first maker-themed event, but it's the first in which it's had a direct hand organising under an independent banner. It's not hard to see why the maker culture aspect may appeal: inside the main hall of the museum, I'm surrounded by exhibits that demonstrate the inventive past of the region, from the output of cotton mills through to a full-sized Avro aircraft suspended from the ceiling.

'We do a lot of making events, but this is the very first MakeFest we've had,' says Williams, speaking up over the noise of an impressive crowd of visitors. 'It's been a really exciting weekend, because we've been able to bring our galleries to life, looking at connections with historical machines and the inventing and making that's gone on in Manchester in the past.'

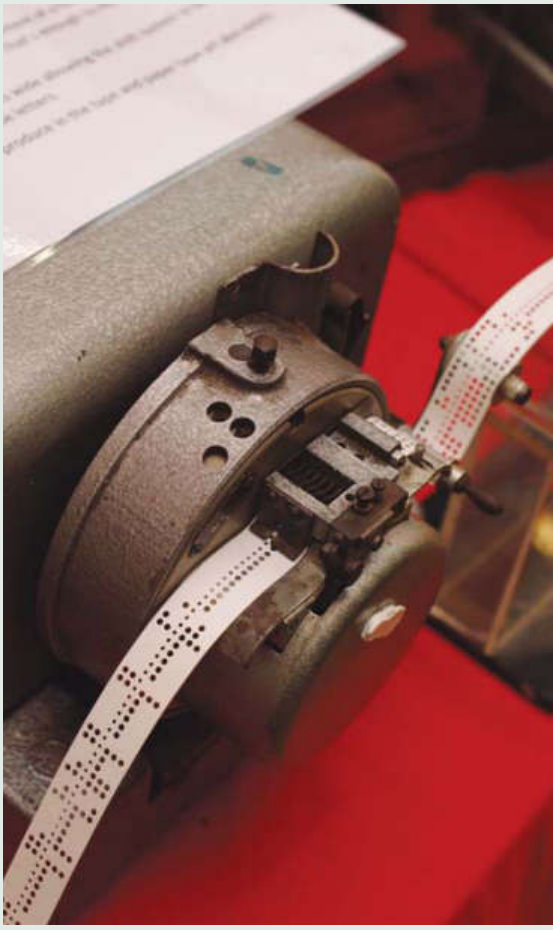
There were far too many amazing exhibitors to detail in just two pages, from the usual soldering workshops to knitting

Matthew Shotton, left, attracted a crowd with the BOrkestra

The BOrkestra – where digital music software on a laptop drives real-world instruments

A day-two failure of the Archimedes Screw required some careful repairs from Ian Norton

Amazeballs participants were given box dimensions but otherwise left to their own devices



For vintage computing enthusiasts, the site of a teletype interacting with paper tape was a real treat

classes, 3D printing and of course plenty of Arduino and Raspberry Pi-powered creations. As such, what follows is a rough selection of personal highlights, starting with an entirely unexpected exhibit: bowls of food.

'These are musical bowls, so when you dunk your hands in either the spaghetti, water or custard, it will play a tune, which is quite fun and it's going down well today,' Rachael Moat, of Manchester Arduino, explains. 'I volunteer at a place called Seashell Trust, which is a school for children with very complex needs, and I use this sort of thing to encourage them to explore new textures and potentially open up their diets, because they'll lick their hands and actually experience new foods.'

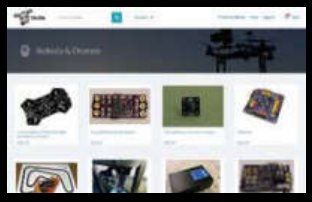
Leaving behind the bowls – powered by a Bare Conductive Touch Board, a review of which will appear in a future column – my next highlight is the B0rkestra, a wonderfully named fusion of digital and analogue audio and an easy exhibit to find: just follow the noise. 'The idea is that electronic music has always been sort of made in computers and you always hear it out of speakers,' explains Matthew Shotton, BBC research and development engineer and one-half of Team B0rkestra. 'We wanted to see if we could turn it on its head a bit and make electronic music using acoustic instruments. Each of our instruments is wired up to a central computer, and then you can use any kind of MIDI sequencing software to make music on it.'

Amazeballs, meanwhile, is a larger collaboration involving several hackspaces and maker organisations in the area. 'Each of these boxes has been built by a different hackspace or a different person within that hackspace,' Lancaster and Morecambe Makers' Ian Norton tells me, taking a break from a day-two running repair on the clever Archimedes screw, which returns ball bearings to the start of the multi-box run, 'and then there's a ball lift at the end to shift it back to the beginning.'

This write-up, sadly, leaves out many other folks I spoke to on the day: the educational chaos of Noisy Toys, the excellent Kids in Space and even the clever Build-a-Bug Workshop which so delighted children. There's only one thing for it, of course: next year, you'll all have to come along with me.

NEWS IN BRIEF

Supplyframe acquires Tindie



Tindie, originally a place to sell crowd-funded gadgets to sell once their campaigns had finished, has been acquired by Supplyframe for an undisclosed sum. Supplyframe, which acquired maker blog Hackaday in 2013, claims it will continue running Tindie as normal following the deal. 'The only changes we're interested in are the ones that make the community stronger,' said Aleksandar Bradic, chief technology officer at Supplyframe, of his company's newest subsidiary. 'We are fascinated with the challenges surrounding the supply chain and will be looking into tools to help sellers improve margins and ship better products.'

INTERVIEW

Ben Gray and the MeArm v1.0

Regular readers will remember my review of the Phenoptix MeArm robotic arm kit, cleverly constructed from a single A4 sheet of laser-cut acrylic, in Issue 133. Since then, inventor Ben Gray has been hard at work on the project, which has just hit a major milestone: the release of design files for the MeArm Version 1.0.

'I spotted a product online and had the tools – or so I thought – to make it. As it turned out, the manufacturer hadn't released any files, just calling its product "open source",' Gray explains of the inspiration behind the project. 'So rather than vent my anger into a website comments section, I set out to build what I thought the product should have been.'

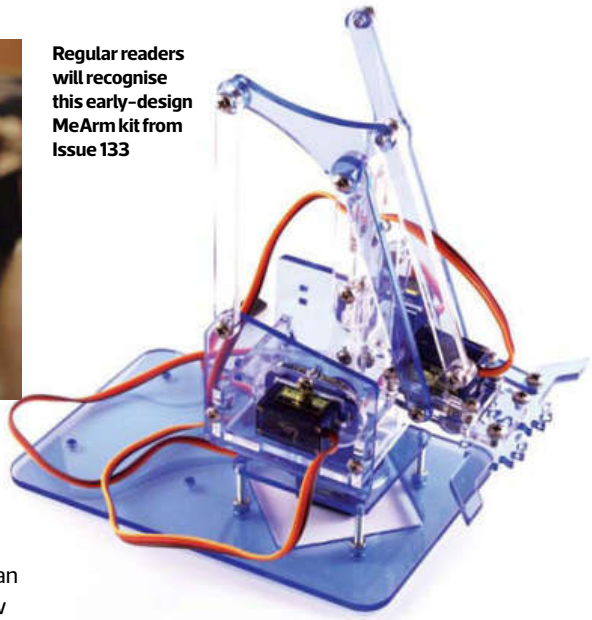
The lack of files for a project claiming to be open source isn't uncommon. Gray even has a name for it – 'open washing'. He defines this as 'using the popularity of open source hardware in the media to market your product without actually releasing any useful information. I have a test you can apply to products claiming to be open source – give yourself ten minutes to find the source files: if you can't find them in that time then it's not open source.'

The MeArm, by contrast, has been open from the start. In fact, he actively encourages the production of derivative designs, even if they're commercial products. 'It's a massive buzz,' he laughs. 'You get a feeling like a hole in your stomach, as if someone has taken your thing, especially if theirs is really good! Once your brain kicks back in, though, you can take a look at what they've done and borrow the clever bits for your design, and getting in touch with them is always a pleasure. Also, as there's no financial penalty for copying the design, they're always happy to tell people where they got the original idea.

Ben Gray, the MeArm's inventor, has a bee in his bonnet about 'open-washing'

'Personally, I've learned a great deal from the open hardware scene, so I really wanted to give something back. Also, I believe that if something is good people will copy it anyway; the open hardware movement allows people to copy and improve your designs.'

One major change since my review is that Phenoptix is no more: Gray has fully plunged into the MeArm project, shutting his popular component shop in order to concentrate on his new company: MeArm Robotics. 'The product seemed to be taking off almost without me,' he recalls. 'I felt that if I didn't leave the rat race I'd be left wondering what could have been. Having run a company before, it didn't feel like too massive a leap, but it's been far tougher than I'd thought.'



Regular readers will recognise this early-design MeArm kit from Issue 133

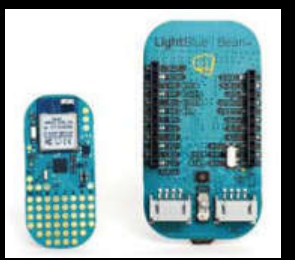
With the design of the arm itself now at a release-ready Version 1.0, Gray is working on other aspects of the project that many makers all too often ignore, distracted by the next idea that swims up from their subconscious. 'It's been clear that more time needs to be spent on the documentation, so that's where we're concentrating right now,' he tells me, as I recall relying on a third-party write-up when building my early-model MeArm. 'Before now, we've dealt with a technical audience who are happy to fill in the gaps themselves. What we're selling now is a kit for beginners, and there's a lot of information to cover!'

Gray has already enjoyed success for a crowd-funded follow-on product, a MeArm controller board dubbed the MeBrain, but he's uncharacteristically coy when asked what's coming next. 'Well, there's a lot in the pipeline,' he teases. 'Watch this space!'

More information on the MeArm project can be found at http://mearm.io CPC

NEWS IN BRIEF

Punch Through Design funds LightBlue Bean+



Punch Through Design, creator of the Arduino-compatible LightBlue Bean, has successfully funded manufacturing of its successor, the Bean+. Like its predecessor, the LightBlue Bean+ combines Arduino features with an on-board Bluetooth radio. Improvements in the new model include Bluetooth Low Energy (BLE) compatibility, solderless pin headers, a rechargeable battery, 16 GPIO pins accessible to end users, plus connections for Seeed Studio's Grove family of add-ons. With nearly $160,000 raised, the company easily exceeded its $30,000 goal on crowd-funding site Kickstarter, and aims to have the first boards sent out to backers by the end of the year.

Gareth Halfacree is the news reporter at www.bit-tech.net, and a keen computer hobbyist who likes to tinker with technology. @ghalfacree

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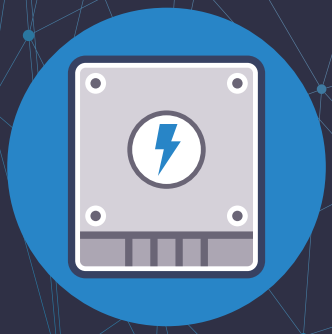

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ANTONY LEATHER'S

Customised PC

Case mods, tools, techniques, water-cooling gear and everything to do with PC modding

Mayhems revamps glass tubing

Last month I looked at Mayhems' glass tubing – a new take on hard tubing that follows on from acrylic and metal. It looked fantastic, but at that point it was still practically at the concept level. However, at the recent Multiplay i-55 event at the NEC in Birmingham, I caught up with Mayhems and the project has already made a lot of progress.

For starters, Mayhems has now increased the wall thickness from around 1.5mm to 2.5mm – a considerable amount – so it's now even stronger. I couldn't even crack the tubing with the previous thickness with a hammer and a fair degree of force, so I'd have no qualms about using this type of tubing now instead of acrylic or metal in strength terms. The interior is a little smaller as a result, but that will have a negligible impact on flow rates.

Mayhems' revised glass tubing (left) sees the wall thickness increasing from around 1.5mm to 2.5mm

Hex Gear created this great PC for MSI using its R40 case, with some help from UK modder John Laveric

In addition, Mayhems says it's looked into offering pre-bent glass tube sections, despite saying last month that bending it was too tricky compared with metal or acrylic tubing.

Sizes are also now more varied; tubing with outside diameters of 12mm, 13mm and 16mm available, with 12mm and 16mm tubing being supported by the likes of EK's hard tube fittings, while other companies such as Alphacool offer fittings for 13mm tubing too. Best of all, the tubing is now available on the Mayhems website, starting at £6.50 inc VAT for a 500mm tube, so head over to **http://mayhems.co.uk/store** if you fancy having a go at glass tubing instead of acrylic or metal.

PC modding thrives at i-55

As I mentioned above, I visited the Multiplay i-55 event last month and I was blown away by the amount of modded PCs and hardware on show. Many of the Dream PCs we reviewed a few issues ago were there, including Overclockers' 8Pack Supernova and Emperor as well as Scan's Barracuda. A lot of the companies had built modded PCs for the event too, with UK modders Daniel Harper and Dave Alcock getting in on the action, along with several systems based on Parvum and Hex Gear chassis.

The place was packed – tens of thousands of people attended over the event's few days. It was great to see so many people interested in PC hardware, and it was clear that the likes of Minecraft and eSports are creating a new generation of PC gamers and enthusiasts; lots of parents with young children attended too – it's great to see a console and smartphone-free event drawing crowds so big and varied.

Many manufacturers and etailers were there as well, including Scan, Overclockers UK, Ebuyer and CCL. Manufacturers such as Asus, MSI,

UK modder Dave Alcock has been busy working on his white modded Phobya Owl case

Aquatuning's stand was the star of the show, with several great-looking PC mods, including the company's own yellow Corsair 750D rig

Gigabyte and Thermaltake had their latest gear on show too, all of which had a modded PC on display to help draw the crowds.

For example, Hex Gear created a great PC for MSI using its R40 case, with some help from UK modder John Laveric, while Overclockers UK had several Parvum Systems cases on show, including one made by the folks at OCUK themselves. The star of the show, though, as far as modding and water cooling were concerned, was the Aquatuning stand. It had several great-looking PC mods, including a yellow machine based on a Corsair 750D, made by the folks at Aquatuning. Meanwhile, UK modder Dave Alcock displayed his work on a white modded Phobya Owl case.

There are some very interesting products in the works too, including a combined GPU waterblock, pump and radiator cooler from Alphacool called the GPX-Pro. It features Alphacool's GPX waterblock, which can be made to accommodate practically any PCB design when you order it. More interestingly, the kit uses standard fittings so it's expandable too. Such a setup could eliminate the need for a separate pump and reservoir and, when combined with a larger radiator and CPU waterblock, it could enable you to water-cool your entire system very easily.

Alphacool's GPX-Pro cooler combines a GPU waterblock, pump and radiator in one unit

Excitingly, the pump was practically inaudible – even with my ear against it, there was no discernible noise. The same can't be said for most all-in-one liquid coolers, so the GPX-Pro could be a very interesting addition to the liquid-cooling scene – there was a triple 120mm-fan radiator version on display too. Also on show was the company's vast array of radiators, as well as selections of its CPU and GPU waterblocks, along with complete water-cooling kits.

L3pipe by Peter Brands

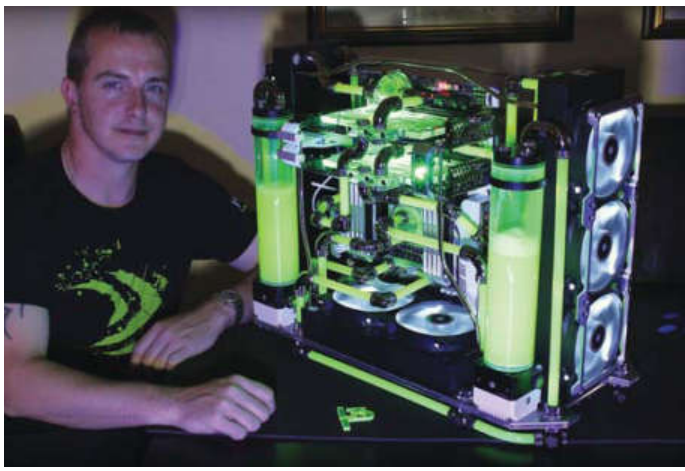
You've probably seen at least one of Peter Brands' many fantastic builds already, either in these pages or on the Internet, but Brands has just completed quite possibly his best project since his famous L3p d3sk PC. Called L3pipe, its foundation is basically made up of some sheets of acrylic and metal sandwiched together, custom-made by Parvum Systems.

Brands then put in a huge amount of work creating the chassis and installing the hardware into the open-air case, with two large triple 120mm-fan radiators at either end and another two smaller radiators in the centre. We don't think we've seen quite so many tube fittings all in one PC before, but if you're dealing with four radiators, four pumps, four reservoirs, two GPU waterblocks, a CPU waterblock and a motherboard waterblock, with acrylic tubing as well, you're going to need an awful lot of fittings.

The end result, as is usually the way with Brands' work, looks spectacular and drew quite a crowd online. What's more, Brands will be talking to **Custom PC** about the mod in our Readers' drives section in next issue. CPC

We don't think we've seen quite this many tube fittings all in one PC before

Peter Brands will be talking to us about L3pipe in our Readers' drives section next issue



Antony Leather is Custom PC's modding editor @antonyleather

How to
Make drive bays disappear

Antony Leather shows you how to magic away any unsightly drive bays in your case, using filler

TOTAL PROJECT TIME / 2 HOURS

Painting your case can make it look fantastic, but before you get the spray can ready, you can also take this opportunity to completely customise your case's aesthetics, get rid of drive bays and heal any battle wounds. You can sand areas flat, get rid of any scratches and dents and, once the paint has been applied, it will look as good as new. The magic ingredient is filler.

Using this filler, you can fill large dents and scratches but, more importantly, you can also fill in entire sections of your case. For example, in our recent Dream PC Labs test, Scan filled in the front 5.25in bays of its SilverStone TJ07 before spraying the case.

The end result is so smooth that you'd never know they were there. We'll be taking a look at how to use filler on your PC case, focusing on filling in some drive bays and then spraying over them to make them disappear.

P38 Easy Sand filler / Most hardware stores

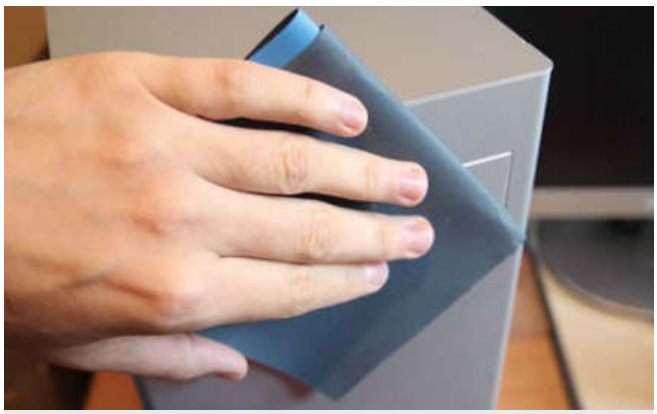
240 and 600-grit sandpaper / Most hardware stores

1 / INSPECT THE AREA TO BE FILLED

You need to make sure the area to be filled is free from objects that can wobble around. Ideally, the area should be flat so that it can be sanded to a smooth finish. You don't need to use any back supports for the filler, as long as the holes are small.

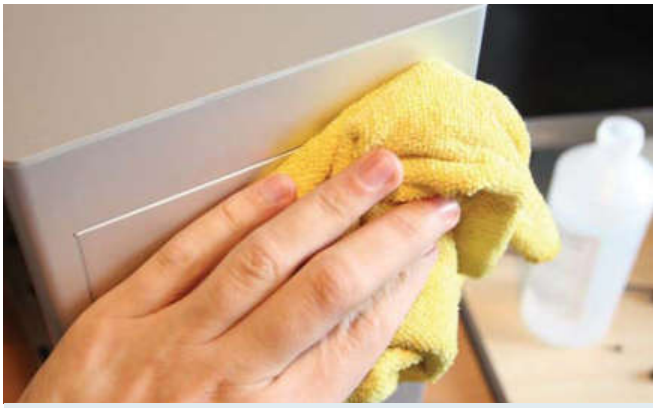
2 / ADJUST FRONT PANEL BLANKING PLATES

If you're filling in 5.25in blanking plates, they need to be tightly secured with screws. If your plates are tool-free and move around, glue them in place so they can't move when you apply the filler.



3 / SAND AREA

The filler adheres best when applied to roughened surfaces, so rub around and over the filling area with 240-grit sandpaper, using no water, until you've scored into the metal or plastic a little.



4 / CLEAN AREA

After the area has been sanded, clean it thoroughly. Use isopropyl alcohol for this job if you have some, or just some warm soapy water. Allow the area to dry naturally of, if you're in a hurry, use a hairdryer on a low heat setting.

5 / APPLY FILLER AND HARDENER

Apply the filler and hardener to a piece of paper or cardboard. You'll only need a tiny amount of hardener – the more you use, the quicker the filler will set, but even this small amount saw it go rock hard in under ten minutes.

6 / MIX COMPONENTS TOGETHER

Once you're sure the area is ready, and that you've used the right amount of hardener, use the included spatula or an old credit card to mix the two components together. Mix them thoroughly but for no more than a minute, or it will start to set.

7 / WORK INTO CORNERS

First, work the filler into any large holes or corners. Here we've pressed it into the corners and holes surrounding our 5.25in bay. Afterwards, allow it to dry, so it will form a supporting layer for a second application that will enable you smooth it off.

8 / APPLY A SECOND LAYER

Mix up some more filler and, once the previous layer has dried, apply the second layer liberally, forming a large area that you can sand down. Don't be afraid to use plenty of filler, but avoid making big peaks and troughs.

9 / SMOOTH OVER FINISH

Finally, before the second layer sets, use the spatula to smooth over the surface, removing excess filler, but being careful not to dig so far into the filler that you catch the edges of the drive bay.

10 / USE 240-GRIT SANDPAPER

The filler will likely be ready to sand in less than 20 minutes, after which you can start sanding with coarse sandpaper. Don't press too hard until you can gauge how quickly you're eating into the filler. You need to sand the filler so it's level with the case surroundings.

11 / USE 600-GRIT SANDPAPER

The filler is level with the case, use 600-grit sandpaper to smooth off the finish, ready for primer. Sand it for five to ten minutes, until all the smaller pits and holes are gone.

12 / CLEAN AREA

Once you've finished sanding, wipe the area with a damp cloth to remove all the filler dust. Any leftover dust can allow the paint to lift once it's dried, so it's essential to get rid of it.

13 / FEEL FOR IMPERFECTIONS

It's usually easier to feel imperfections than to see them, so use your fingers to check the area. If you feel any big pits, you can fill them again or sand the surrounding area.

14 / APPLY PRIMER

Apply primer ready for your choice of paint. Typically, primer is grey and can be bought in most hardware stores. Apply a few layers, then sand it down using 600-grit sandpaper. If you spot any pits and troughs in the primer, fill them or sand them appropriately.

15 / ALLOW TO DRY

Once you've sanded down the primer and applied several more coats, take a look at the finish. Once dry, you can proceed and apply your paint or go back and touch up some areas with filler or sandpaper. CPC

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How to Remove acrylic scratches

Accidentally scraped your side panel window? Antony Leather shows you how to remove scratches from acrylic panels

TOTAL PROJECT TIME / 2 HOURS

The use of acrylic has enabled PC cases to become lighter, cheaper and more colourful, and it's a very handy material when building your own case too, as it's easy to cut and bend. However, as acrylic is fairly soft, it's also very prone to picking up scratches. Unlike painted metal, you can't just respray your case to get rid of scratches on acrylic, or just sand them out. They can look particularly unsightly on side windows or front fascias too.

Thankfully, you don't have to be stuck with a ruined case exterior, as it's possible to polish out even fairly deep scratches, bringing the surface back to new again. There are plenty of plastic polishes available, which can revive scratched acrylic and buff up the surface if it's lost its shine too. Couple this polish with some fine-grit sandpaper and a bit of elbow grease, and your case will be scratch free in no time.

TOOLS YOU'LL NEED

2,000 and 3000-grit sandpaper / Most hardware stores

Xeropol plastic polish / www.amazon.co.uk

1 / INSPECT THE SCRATCH

All scratches are different – some are just swirly surface marks, while others cut quite deep into the plastic. For serious scratches, you'll need to use 2,000-grit sandpaper initially, while lighter scratches will only need 3,000-grit paper or maybe no sandpaper at all.

2 / CHECK THE MATERIAL

This method only works with glossy, uncoated side panel windows and acrylic – polishing a coated material using our method will remove any matt coating, and probably make it look worse. If your acrylic is coated, don't try to remove the scratches using this guide.

3 / REMOVE PANEL

If possible, remove the scratched panel from your case to make this work easier and avoid accidentally sanding into paintwork. Most case fascias can be easily removed, and even side panel windows often just use clips to hold them in place.

4 / CLEAN AREA

To make sure the polish can reach the acrylic, give the area a thorough clean with warm soapy water. Then wipe off any scuff marks and residue from whatever scratched the case with a sponge – the scratches should be the only marks left.

5 / WET AREA

The sandpaper works best when wet, as it can then create a grinding paste for a super-smooth finish and help to lubricate the paper. Apply a small amount of water to the area with which you're working and continue to do so every few minutes while you work.

6 / USE SANDPAPER

Start with 3,000-grit sandpaper, rubbing the area in circular motions for two minutes. If the scratches are still clearly visible, switch to 2,000-grit paper until they can't be detected with your fingernail. Then switch back to the 3,000-grit paper to smooth over the area.

7 / APPLY XERAPOL POLISH

The polish can remove fine scratches itself, but can also be used after 3,000-grit sandpaper has been used. Apply a small amount to the scratched area and buff with heavy pressure for five minutes then inspect the area.

8 / BUFF TO A SHINE

Clean the Xerapol off the area and buff up the surface. You might need to use standard household polish to completely remove the Xerapol. If you spot other scuffs and marks, reapply some Xerapol and continue the process until you're happy with the finish.

9 / INSPECT FOR SCRATCHES

Only after you've buffed the surface to a shine will you know if you've removed all the scuffs and scratches. Don't be afraid to use the polish again and, if necessary, repeat the sanding process until the scratches have been removed. CPC

Readers' Drives

FLUX

Inspired by modern architecture and gemmology, goldsmith Femke Agnes Toele created this aluminium and Plexiglas NUC PC with custom water cooling

/MEET THY MAKER

Name Femke Agnes Toele (aka F.A.T.)

Age 27 years young

Location Schoonhoven, The Netherlands' 'silver city'

Occupation Goldsmith and silversmith

Main uses for PC Photo and video editing

Likes Being a goldsmith. Case modding, which feels like 'modern' silversmithing – in the old days silversmiths made items such as cutlery because there was no IKEA. Now everyone uses computers, but there are limited design options if you want a good-looking computer. I also love motorbikes (although I had to sell mine), and my blue parrotlet friend, Pixel

Dislikes Running out of dental floss, having to sell my motorbike, crappy Wi-Fi, plugging in my USB drive the wrong way

CPC: What originally inspired you to build FLUX?

Femke: If you look at modern architecture, sometimes you see very refreshing new ideas and beautiful structures. There's an architect who makes very special buildings called Zaha Hadid, and she's been a great inspiration for my first ideas about FLUX. Also, if you look at the Beijing Olympics Aquatics Pool (not designed by Zaha Hadid), you can see the similarities with FLUX. I noted this particular building years ago when I had to do research for an art class at school. The image stayed with me throughout the years. The cell structure is complex, but it still looks clean and well organised. The colour scheme of the build was very easy because I always tend to go for blue and white/silver/steel colour combinations.

CPC: Where does the name come from?

Femke: As I'm a goldsmith, gemmology was a part of the course at my school in Schoonhoven. In gemmology, you learn chemical aspects of gemstones and minerals – it's like chemistry, but very specialised. You have to determine the properties of a lot of gems, such as diamonds, sapphires and rubies to know if they're synthetic or real gemstones. Nowadays, there are a lot of synthetic gemstones and sometimes it's hard to tell the real ones from the synthetic ones.

The process of making synthetic gemstones is very interesting. When you want to make a synthetic gemstone, you start off with a 'flux' which is a substance that will transform under heat and pressure into a gemstone. I thought of my FLUX build similarly – I had to create it using a lot of heat (work) and pressure (time). The Plexiglas in the build also looks like it's starting to move and settle into its final shape.

CPC: What specs did you choose and why?

Femke: In the bit-tech Intel NUC competition, all the contestants had to work with Intel's new NUC the 5i5RYK motherboard. It's a complete system, apart from the RAM and SSD, which you still have to install yourself. It's basically the perfect HTPC foundation!

CPC: What other mods have you built?

Femke: I've built a few systems now. The first one was called Little Scratch and was made for the ECS Modmen competition two years ago. It was designed to be compact and different from usual case mods – a computer you'd like to place on your desk as a sculpture. It ended up in the top five in the contest, and I took it to Computex in Taiwan – that was the moment when my passion for case modding started.

Afterwards, I worked on my Polar (http://tinyurl.com/FATPolar) build, which was also inspired by FLUX. Then, for Gamescom 2015, I made Aegis (http://tinyurl.com/FATAegis), which was based on the BitFenix chassis, and started on the Prototype Atlas build for BitFenix too. I'm also working on some top-secret builds that are still in progress, but they will soon be revealed!

CPC: What difficulties did you come across?

Femke: All the techniques I used to build FLUX were experimental. I knew the principles, but didn't know whether they would work. In the end, it thankfully all worked out very well! However, of course there are always a few parts that could have gone more smoothly, such as the water-cooling loop. Custom water cooling was new to me when I started FLUX, and it was quite a struggle to fit all the parts into that tiny case. Filling the loop was also a tedious process, but thankfully there were no leaks.

CPC: What materials did you use?

Femke: FLUX is made from aluminium, laser-cut Plexiglas and PLA printed parts. The base and top frame are made of aluminium – it's easy to work with aluminium, and it looks really attractive with the sandblasted finish.

The eye-catching part of the build, though, is the Plexiglas top cover. I first made the aluminium frame and then melted the Plexiglas in the oven. When it was flexible and hot enough, I pressed the Plexiglas into the frame by sitting on it. That was the only way

SEE THE FULL PROJECT LOG:
http://tinyurl.com/FATFLux

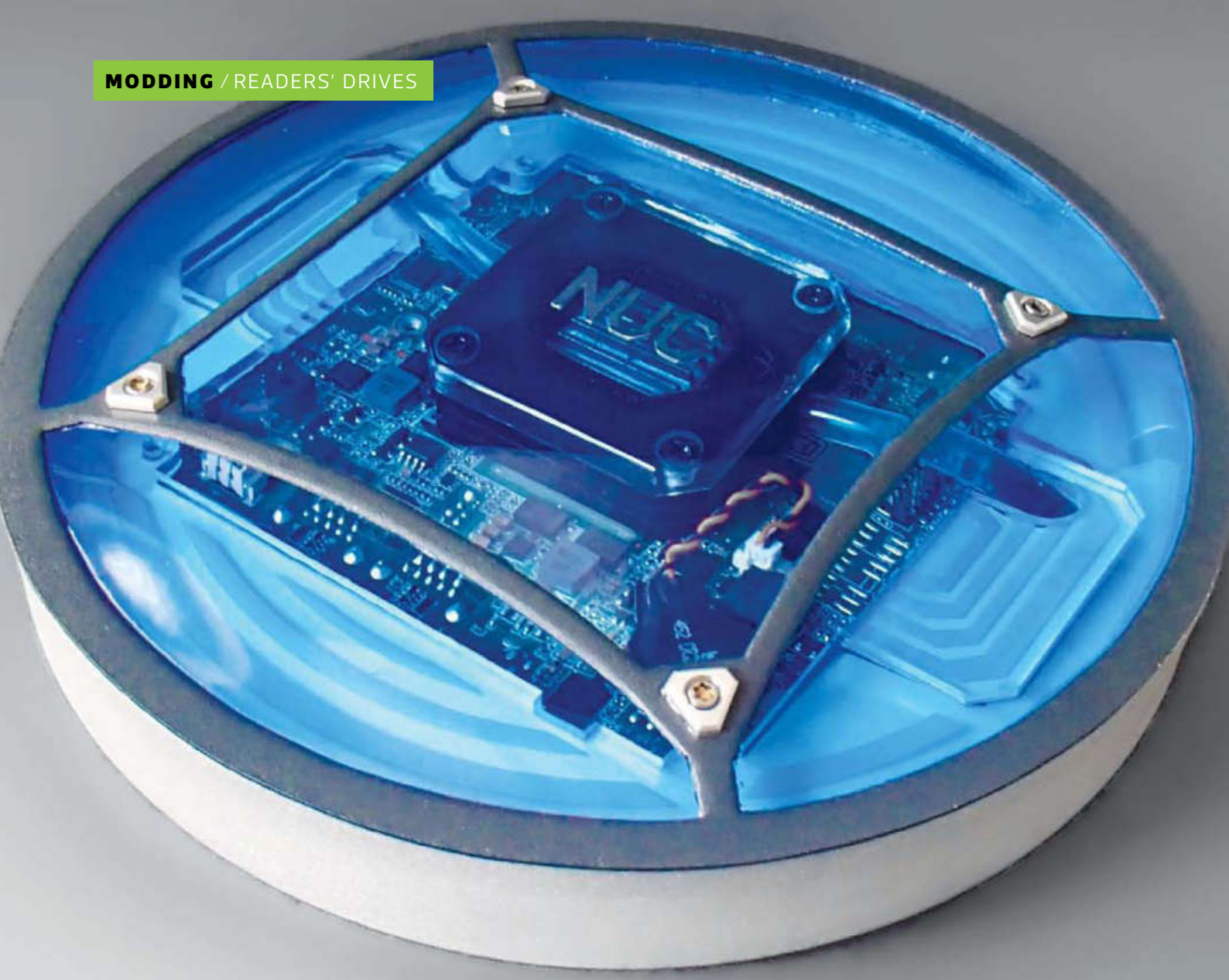
I could put enough weight on the frame so that the Plexiglas would bulge out like bubbles ☺proper butt power! I could have used a different technique, but sitting on it was a good way to show how you can achieve spectacular results without using fancy expensive machinery.

CPC: What tools and machinery did you use?

Femke: The aluminium was formed on a lathe by metal spinning, using a handmade wooden mould ☺aluminium is the perfect metal for this technique. Meanwhile, some of the Plexiglas parts were cut with a laser to get a quick start, and then endlessly adjusted by hand, which involved lots of filing, cutting and sanding. I also used a 3D printer to print the

FULL SYSTEM SPECS

CPU Intel Core i3-5010U
Graphics card Integrated Intel HD Graphics
Memory 4GB Corsair Value Select DDR3 SODIMM
Case Scratch build
Motherboard Intel NUC5i3RYK
Storage 80GB Intel M.2 SSD
Cooling Custom water-cooling loop



PLA mounting plate – 3D printing takes a lot of time, though, and the result of the printed material isn't always perfect either.

CPC: What media interest has FLUX attracted?
Femke: The project has been featured in bit-tech's Intel NUC Competition 2015, together with four other awesome projects. What's more, in the final public voting round on bit-tech's modding forum, FLUX ended up in first place! After the final pictures were finally published, a lot of tech sites posted the pictures on their websites or social media pages too. The Dutch tech website **http://tweakers.net** wrote a really cool article about FLUX, and Intel Netherlands posted about FLUX on Twitter as well.

CPC: How long did the build process take?
Femke: In total, we all had two months to finish the project, which sounds like plenty of time, but you need to have a tight schedule. Of course, the stress kicks in at the last minute as well.

CPC: What did you learn from the build process?
Femke: The process of building FLUX was an eye-opener for me. A lot of the techniques planned for the build went very smoothly, but putting it all together was the trickiest part – the biggest lesson learned was not to underestimate the work involved with the final assembly.

CPC: Are you happy with the end result, and is there anything you'd do differently if you built it again?
Femke: I'm absolutely very happy with this project. The shape and colour scheme had been on my modding wish list for a long time, and FLUX was the perfect project to show it off!

I wanted to show lots of different techniques in the build log too. If I built FLUX again, though, I'd use a different mounting plate – I'd probably use a milled aluminium plate, which would look much better than the 3D printed PLA plate. CPC

BE A WINNER

To enter your machine for possible inclusion in Readers' Drives, your mod needs to be fully working and, ideally, finished based in the UK. Simply log on to **www.bit-tech.net** and head over to the forums. Once you're there, post a write-up of your mod, along with some pics, in the Project Logs forum. Make sure you read the relevant rules and advice sticky threads before you post. The best entrant each month will be featured here, where we'll print your photos of your project and also interview you about the build process. Fame isn't the only prize; you'll also get your hands on a fabulous selection of prizes – see the opposite page for details.

Win all these prizes!

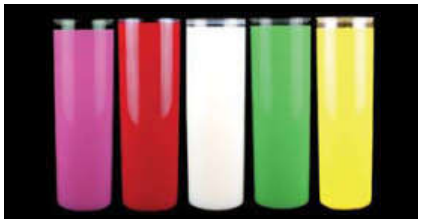
We've teamed up with some of the world's leading PC manufacturers and retailers to offer this great range of prizes to each lucky Readers' Drives winner. If your creation is featured in the magazine then you'll walk away with all of the prizes listed on this page, so get in your entries!

Corsair graphite Series 230T case and RM 550w Modular power supply

TOTAL VALUE £150 inc VAT / **MANUFACTURER** www.corsair.com

Corsair believes that a great PC starts with a great ca
The Corsair Graphite Series 230T is a compact expression of this core philosophy. With stylish looks and a choice of three different colours, it packs in a remarkable number of features to provide builders with tonnes of room for expansion and amazing cooling potential. Like all Corsair cases, it's built using the finest materials and finished to the highest standards, so it will withstand several years of upgrades. Plus, to make sure it stand outs from the crowd, the 230T features Corsair's new Air Series LED high-airflow fans, providing distinctive lighting with low-noise, high-airflow cooling.

Just as a quality case is essential to building a quality PC, a high-performance, a high-quality power supply is also a vital ingredient. The all new RM series has been built from the ground-up to deliver unmatched reliability alongside 80Plus Gold efficiency, and all with the absolute minimum of noise. It uses specially optimised quality parts to reduce sound at the component level, and it's completely silent below 40 per cent load, thanks to its Zero RPM fan mode. It's also fully modular, allowing for the maximum amount of flexibility during installation. With a Corsair Graphite 230T case and an RM 550W Modular power supply at the heart of your build, you'll have the foundations for a truly awesome gaming machine.



Mayhems coolant and dyes

VALUE £50 inc VAT / **MANUFACTURER** www.mayhems.co.uk

Cooling performance is only one part of the equation when it comes to kitting out your rig with custom water-cooling gear. The other major bonus is that all those tubes and gleaming fittings just make your PC look damn sexy, and they look even better when they're pumped full of fancy coloured coolant. As such, we're particularly pleased to have the folks at Mayhems now on board with Readers' Drives; they're currently offering two 1-litre bottles of Mayhems' Pastel Ice White coolant, along with a selection of five dyes, so you can choose the colour that best complements your PC. Check out the blue coolant in our own mini PC mod on the cover of Issue 109 for an example of what's possible with some Mayhems coloured coolant.

Phobya Modding Kit

VALUE £50 inc VAT **MANUFACTURER** www.phobya.com, www.aqua-tuning.co.uk

The Phobya modding kit is designed with the modder in mind, offering great value for money and quality products. The kit includes Nano-G 12 Silent Waterproof 1,500rpm multi-option fans, which use an innovative fan-blade design. As standard, the fans include braided black cables to keep your case looking as neat as possible. The fans are also supplied with a special cable that lets you run the fan at 5V rather than 12V, reducing the noise emitted in order to help you to build a silent system.

The kit also includes the 60cm Phobya 3-pin Molex to 4x 3-pin Molex Y-cable. This pre-braided extension cable gives you extra routing options in your case, and it also enables you to run up to four fans from one compatible motherboard header. Meanwhile, the Phobya SATA 3 cables included in the kit offer the same great quality braiding as the rest of the Phobya range, while also securing your connection with latched connectors. As well as this, the kit includes the Phobya SlimGuide Controller, which gives you the option to vary the speed of other fans in your case, while the Phobya TwinLEDs let you shine a light on your mods.

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CUSTOM PC REALBENCH 2015

in association with ASUS

Give your PC a workout with our new benchmark suite, and see how your rig compares to other readers' machines

BENCHMARK YOUR PC

Download the benchmarks from www.asus.com/campaign/Realbench and, before you run them, disable any power-saving technologies in your BIOS that change your CPU clock speed, or the leaderboard won't record your overclock frequency properly. To post a score on the leaderboard, go to Save Upload File in the RealBench 2015 app's Results menu, and save your results in an RBR file. You need to select Offline Uploads on the leaderboard site, sign up for an Asus account and upload your file.

Gimp

We use Gimp to open and edit large images. Unlike our previous Gimp test, this one uses more than one CPU core, although it's still more sensitive to clock speed increases than to more CPU cores.

Handbrake H.264 video encoding

Our heavily multi-threaded Handbrake video encoding takes full advantage of many CPU cores, pushing them to 100 per cent load.

LuxMark OpenCL

This GPU compute test is the only synthetic part of our suite, although the renderer is based on the real LuxRender physically based rendering software. As 3D rendering is a specific workload that not everyone will use, and because OpenCL support isn't standard in most software, this section is given just a quarter of the weighting of the other tests in the final score.

Heavy multi-tasking

Our new multi-tasking test plays a full-screen 1080p video, while running a Handbrake H.264 video encode.

Scores

RealBench 2015 breaks down the scores for each test, then gives you a total system score and a percentage reference score.

On an Intel system, the 100 per cent reference score comes from a stock-speed Core i7-4790K, with 16GB of Corsair 2,400MHz DDR3 memory, a 240GB OCZ 150 SSD, an Asus Maximus Gene VII motherboard and an Nvidia GeForce GTX 780 3GB graphics card.

On an AMD system, the 100 per cent reference score comes from a stock-speed A10-7850K APU, with 8GB of Corsair 2,133MHz DDR3 memory, a 256GB Plextor M5 Pro SSD and an Asus A88X-Pro motherboard, using the APU's integrated graphics. CPC

SHOUT OUTS!

Wow, 8Pack has done it again! This time, OCUK's veteran overclocker has hit the top spot with a Core i7-5960X running at an incredible speed of 5.5GHz (125MHz x 44), producing an amazing system score of 275,683. Also, kudos to our new entries in the top 20 this month – mark.gee93 and olthepol.

CHROME WARNING

At the moment, Google's Chrome browser flags up the RealBench 2015 download as potentially harmful, and we're aware of this issue. The file is perfectly safe, however – please ignore this warning.

CUSTOM PC REALBENCH 2015 LEADERBOARD

RANK	SYSTEM SCORE	REFERENCE	USERNAME	MOTHERBOARD	CPU	CPU CLOCK	MEMORY	PRIMARY GPU
1	275,683	240.9%	8pack	Asus Rampage V Extreme	Intel Core i7-5960X	5.5GHz	16GB Kingston 3000MHz	Nvidia GeForce GTX Titan X
2	233,375	203.9%	ian.parry3	Asus Rampage V Extreme	Intel Core i7-5960X	4.6GHz	32GB G.Skill 3200MHz	Nvidia GeForce GTX Titan X
3	219,415	191.7%	Luke@DinoPC	Asus Rampage V Extreme	Intel Core i7-5960X	4.6GHz	16GB Corsair 3276MHz	Nvidia GeForce GTX Titan X
4	206,273	180.6%	stuart	Asus Rampage V Extreme	Intel Core i7-5960X	4.41GHz	16GB Corsair 3000MHz	Nvidia GeForce GTX 780 Ti
5	201,446	176.0%	CustomPC	Asus Rampage V Extreme	Intel Core i7-5960X	4.3GHz	16GB Corsair 2666MHz	Nvidia GeForce GTX Titan X
6	197,964	173%	Carbonleg	Asus X99-E WS	Intel Core i7-5960X	Not reported	32GB Corsair 2400MHz	AMD Radeon R9 200 Series
7	189,230	165.3%	shadowsrayne	Asus Rampage V Extreme	Intel Core i7-5960X	4.2GHz	32GB Corsair 2133MHz	Nvidia GeForce GTX 980
8	172,828	151%	mdottwo	Asus Rampage V Extreme	Intel Core i7-5820K	4.4GHz	16GB G.Skill 2766MHz	AMD Radeon R9 200 Series
9	167,332	146.2%	grozzie	ASRock X99M Killer	Intel Core i7-5930K	4.48GHz	32GB Kingston 3071MHz	AMD Radeon R9 200 Series
10	167,002	145.9%	maliepaard.chris	MSI X99S SLI Plus	Intel Core i7-5820K	4.49GHz	16GB Corsair 3000MHz	Nvidia GeForce GTX 980 Ti
11	166,078	145.1%	Chris_Waddle	Asus Rampage IV Black Edition	Intel Core i7-4930K	4.72GHz	16GB Corsair 2464MHz	Nvidia GeForce GTX Titan X
12	165,512	144.6%	Penfold	Asus X99-Deluxe	Intel Core i7-5820K	4.5GHz	32GB Corsair 2333MHz	AMD Radeon R9 200 Series
13	165,151	144.3%	mark.gee93	Asus Rampage V Extreme	Intel Core i7-5930K	Not reported	16GB Corsair 3200MHz	Nvidia GeForce GTX 980 Ti
14	163,650	143%	shaunhanson	MSI X99S SLI Plus	Intel Core i7-5820K	Not reported	16GB Corsair 2133MHz	Nvidia GeForce GTX 980
15	163,400	142.7%	andy	MSI X99S Gaming 7	Intel Core i7-5820K	4.4GHz	16GB Corsair 2666MHz	Nvidia GeForce GTX 980
16	163,065	142.5%	viperz	Asus X99-Deluxe	Intel Core i7-5820K	4.48GHz	16GB Corsair 2400MHz	Nvidia GeForce GTX 970
17	160,855	140.5%	imre_grozner	ASRock X99M Killer	Intel Core i7-5930K	4.19GHz	32GB Kingston 2666MHz	AMD Radeon R9 200 Series
18	158,072	138.1%	olthepol	Asus X99-Deluxe	Intel Core i7-5930K	Not reported	16GB Crucial 2400MHz	Nvidia GeForce GTX 970
19	157,611	137.7%	andrew_mcse	Asus Rampage IV Black Edition	Intel Core i7-4930K	4.49GHz	16GB Corsair 2400MHz	AMD Radeon R9 200 Series
20	156,212	136.5%	bennunn	Asus X99-Deluxe	Intel Core i7-5820K	4.08GHz	32GB Corsair 2448MHz	Nvidia GeForce GTX 980 Ti

Folding@Home

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MILESTONES THIS MONTH

USERNAME	POINTS MILESTONE
grozzie	20000
dbmitch84	30000
Capt-Camm-Nett	40000
Pickles96	50000
tallandgentle33uk	60000
Arcem	70000
LEACHIE007	70000
wir3d123	70000
pig_farmer_uk	80000
nbowling	100000
smiler	100000
Ayeska	200000
Grimm808	200000
Mr_Blue_Jam	200000
roosauce	200000
Kentara	300000
mort6dav3	300000
FurstyFerret	400000

USERNAME	POINTS MILESTONE
Mike1419	400000
TimmyH	400000
TheTomBoy	500000
Sonic67	600000
The_FFrey	600000
Just_G	700000
scoobyzilla	800000
Bob_D	900000
b1ll55t34m	1000000
Catflaps	1000000
jamiesp17	1000000
ManxBob	1000000
MrDevious	1000000
Pickles	1000000
PURE	1000000
QuasarGreg	1000000
siddallj	1000000
Simbouncer	1000000

USERNAME	POINTS MILESTONE
tastyradiskull	1000000
anadir2	2000000
Bobthetoolnut	2000000
RaistlinRTCW	2000000
varnis	2000000
bigrew	3000000
Damien_Tanner	3000000
robertmather	3000000
ittoms	4000000
SirBenjaminNunn	4000000
techknowledgey	5000000
andboo1	6000000
Liam266	7000000
Werewolf_Legs	7000000
ZeDestructor	7000000
Allan_Smith	8000000
GreenDemon360	8000000
Ken_Swain	8000000

USERNAME	POINTS MILESTONE
Tommye123	8000000
toothytech	10000000
Trunkey	10000000
slowpurple	20000000
Little_Willie	30000000
Andy_J	40000000
BeezaBob	50000000
Maglor	50000000
Cmaxx	60000000
Dickie	90000000
Roveel	100000000
Laguna2012	200000000
TheFlipside	200000000
HHComputers	400000000
piers_newbold	600000000

WHAT IS FOLDING?

Folding@home uses the spare processing cycles from your PC's CPU and graphics cards for medical research. You can download the client from **http://folding.stanford.edu** and our team's ID is 35947. Once you pass a significant milestone, you'll get your name in the mag. You can also discuss folding with us and other readers on the **www.bit-tech.net** forums.

TOP 20 OVERALL

RANK	USERNAME	POINTS	WORK UNITS
1	Nelio	2,400,024,645	136,674
2	DocJonz	1,353,147,963	178,928
3	coolamasta	773,196,219	171,515
4	Scorpuk	649,179,278	22,469
5	piers_newbold	611,306,242	44,247
6	StreetSam	570,985,851	90,228
7	Dave_Goodchild	465,448,860	119,598
8	PC_Rich	442,769,248	77,625
9	HHComputers	427,247,906	20,687
10	johnim	422,773,360	81,215
11	Slavcho	345,598,392	34,220
12	Lordsoth	307,710,808	94,812
13	The_M2B	296,613,895	58,339
14	phoenicis	250,044,587	95,660
15	Laguna2012	220,107,408	20,722
16	Wallace	212,477,027	6,204
17	zz9pzza	211,014,628	15,794
18	TheFlipside	200,239,649	21,942
19	Desertbaker	199,943,744	17,206
20	KevinWright	171,557,437	29,688

TOP 20 PRODUCERS

RANK	USERNAME	DAILY POINTS AVERAGE	OVERALL SCORE
1	DocJonz	2,463,048	1,353,147,963
2	piers_newbold	1,273,358	611,306,242
3	PC_Rich	1,034,002	442,769,248
4	Laguna2012	1,015,670	220,107,408
5	Scorpuk	857,103	649,179,278
6	apeman556	678,037	158,324,586
7	coolamasta	660,808	773,196,219
8	Desertbaker	654,091	199,943,744
9	Dickie	647,137	96,877,203
10	HHComputers	610,632	427,247,906
11	Lordsoth	552,148	307,710,808
12	johnim	511,477	422,773,360
13	The_M2B	486,725	296,613,895
14	Roveel	479,214	113,604,596
15	daxchaos	397,526	18,944,039
16	Andy_J	363,905	41,179,521
17	Nelio	294,105	2,400,024,645
18	Cmaxx	256,134	60,918,049
19	Maglor	252,455	53,530,416
20	slowpurple	229,933	22,439,075

JAMES GORBOLD / HARDWARE ACCELERATED

THE MAGIC OF ILLUSION

VR is nearly here and it's finally come of age, argues James Gorbold

I've waited almost a year for the 3K ultra-widescreen IPS monitors with G-Sync that were announced at CES. The wait was so long, in fact, that I'm now considering skipping this upgrade altogether and going for a VR headset when they first go on sale early next year. After all, a display upgrade is such a big expense that it's only worth it when there's a huge change in quality or experience.

A VR headset is just that – a change in experience unlike anything before. Well, not quite anything. I've been a VR enthusiast for years, but early VR headsets were too bulky, the resolution wasn't high enough and they were far too laggy.

I remember as a young journalist in the 1990s being very excited to have a sneak peek at a (unreleased) Sony headset with Unreal Tournament and marvelling at the view, before finding that after two minutes, I had almost strangled myself with the mass of cables, not to mention having a sore neck from the ridiculously heavy contraption. I daresay I probably looked a little weird too, as I found it necessary to a lay a dark jumper over my head to prevent light bleeding in from the real world and distracting me from the virtual world.

In contrast, the two most prominent models of the new wave of VR headsets, the Oculus Rift and HTC Vive, are all about drawing you into a virtual world. I challenge anybody who has been lucky enough to try the Portal demo with the Vive not to be engaged as GLaDOS taunts you. A part of this demo also successfully tricked the 'flight' routine hardcoded into my DNA into taking an uncertain step backwards, as the floor tiles started collapsing underneath me.

I challenge anybody to try the Portal demo with the Vive and not be engaged as GLaDOS taunts you

There are still problems and limitations, of course – most notably, the cables connecting the headset to your PC. This isn't too much of a problem in cockpit-based games, such as racing games, and flight and space simulators, as your in-game avatar is sitting down just like you, so you can easily swivel around in a chair without too much discomfort.

However, playing a first-person game is more problematic – as soon as you step onto the cable or bump into a real-world object, the illusion of being in the virtual world is obliterated by the intrusion of the real-world sensation. I'm sure this situation will get better once we have wirelessly connected headsets. Resolution and responsiveness could be better too, but with each prototype, both the Rift and Vive have edged closer to greatness.

For me, the Vive edges ahead of the Rift at the moment, mostly because it includes a pair of wireless batons for interacting with the virtual world, instead of a gamepad or joystick. What would really elevate the Vive to greatness is a swords and sorcery game where you can use the batons to swing melee weapons around – an action that's hard to simulate with a keyboard and mouse.

However, I suspect it will be a while before the Vive is responsive enough to let you perform fast and accurate sword moves with the batons.

Either way, early 2016 when the Rift and Vive are expected to go on sale will be a very exciting time to be a PC gamer, especially as both devices are designed to be 'PC first' and haven't been compromised to make them compatible with current consoles. CPC

James Gorbold has been building, tweaking and overclocking PCs ever since the 1980s. He now helps Scan Computers to develop new systems.

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